

Louvain School of Management

Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence?

**An exploratory research on ethical and technological
issues in the healthcare sector**

Author: Meriyem Sarikaya

Supervisor(s): Carlos Desmet

Academic year 2020-2021

Acknowledgment

It is with happiness that I finish this 5-year journey at the Université Catholique de Louvain with this interesting and challenging thesis.

First, I wanted to thank my supervisor, Mr Desmet for his limitless availability, for encouraging me, sharing with me his knowledge and pushing me to a better level with his feedbacks and advices.

I would also like to thank all the professionals who participated in the realisation of my thesis for their time, contribution and kindness which helped me to create a relevant content.

I would like to thank all the people who supported me during my thesis journey as well as my academic journey. I would like to especially thank my parents, Abdilkadir & Emine Sarikaya for supporting, encouraging and always pushing me to go beyond my abilities. Moreover, I would like to express my extreme gratitude to my sisters, brother and the rest of my family and friends for their infinite support.

Finally, I would especially like to thank Bryan Sohy for his incommensurable support, his precious advice, feedbacks, encouragements, comprehension and long hours work during those five incredible years.

Table of Content

TABLE OF CONTENT	II
INTRODUCTION	1
1.1 CONTEXT & CHALLENGES	1
1.2 LITERATURE REVIEW METHODOLOGY	3
1.3 RESEARCH QUESTION	4
LITERATURE REVIEW	4
2. ARTIFICIAL INTELLIGENCE	4
2.1 WHAT IS ARTIFICIAL INTELLIGENCE?	5
2.1.1 DEFINITION AND APPARITION	5
2.1.2 MACHINE LEARNING, THE AI FOR STRUCTURED DATA	5
2.2 HEALTHCARE DIGITAL TRANSFORMATION.....	7
2.2.1 CURRENT AI DISCOVERIES.....	7
2.2.2 OVERCOMING ETHICAL AND TECHNOLOGICAL CHALLENGES.....	9
2.2.3 ADVANTAGES OF TRUSTING MACHINE RATHER THAN HUMAN.....	14
2.2.4 DEVELOPED COUNTRIES VS EMERGING COUNTRIES	16
2.2.5 CONCLUSION AND POTENTIAL SOLUTIONS	17
3. BLOCKCHAIN AND HEALTHCARE	17
3.1 WHAT IS BLOCKCHAIN	18
3.1.1 DEFINITION.....	18
3.1.2 A BRIEF HISTORY OF BLOCKCHAIN	18
3.1.3 THE BUSINESS IMPACTS.....	19
3.2 THE TECHNOLOGY BEHIND BLOCKCHAIN	20
3.2.1 HOW DOES BLOCKCHAIN WORK?	20
3.3 BLOCKCHAIN'S CHARACTERISTICS.....	26
3.3.1 BLOCKCHAIN IMPLEMENTATION IN HEALTHCARE.....	26
3.3.2 BENEFITS OF BLOCKCHAIN	26
3.3.3 DRAWBACKS OF BLOCKCHAIN	29
3.3.4 SOME APPLICATION	32
4. ARTIFICIAL INTELLIGENCE AND BLOCKCHAIN AS WORKING TOGETHER.....	33
4.1 BLOCKCHAIN AND AI FUTURE TOGETHER	34
4.1.1 BLOCKCHAIN AND AI IN THE HEALTHCARE SECTOR	34
4.1.2 CAN BLOCKCHAIN HELP AI?	34
4.1.3 ADVANTAGES AND SIGNIFICANT FEATURES FOR ARTIFICIAL INTELLIGENCE BASED BLOCKCHAIN	35
4.1.4 CHALLENGES TO INTEGRATE AI AND BLOCKCHAIN	39
4.1.5 TYPES OF BLOCKCHAIN USED WITH ARTIFICIAL INTELLIGENCE.....	40
4.1.6 SOME APPLICATIONS	40
5. CONCLUSION & FUTURE	41
EMPIRICAL RESEARCH	42
6. METHODOLOGY	42

6.1	GENERAL METHODOLOGY	42
6.2	METHOD FOR DATA COLLECTION.....	42
6.3	SIZE AND COMPOSITION OF THE SAMPLE	44
6.4	DATA ANALYSIS METHOD	45
7.	<u>HYPOTHESIS</u>	<u>46</u>
8.	<u>RESULTS</u>	<u>46</u>
8.1	BLOCKCHAIN	46
8.1.1	HOW WOULD YOU DEFINE BLOCKCHAIN?	46
8.1.2	WHAT ARE THE CHARACTERISTICS OF BLOCKCHAIN?	47
8.1.3	WHICH TYPE OF BLOCKCHAIN FOR HEALTHCARE?	51
8.2	ARTIFICIAL INTELLIGENCE	52
8.2.1	WHAT IS AI?.....	52
8.2.2	WHAT ARE THE AI ISSUES?	53
8.3	BLOCKCHAIN AND AI	55
8.3.1	AI AND BLOCKCHAIN GENERAL IDEA	55
8.3.2	DATA MANAGEMENT	57
8.3.3	DISCRIMINATION AND UNFAIR BIASES	59
8.3.4	TRUST IMPROVEMENT	60
8.3.5	EXPLAINABLE AI	61
8.3.6	PATIENT MONETIZATION	62
8.3.7	EMERGING COUNTRIES	63
8.3.8	ISSUES FOR INTEGRATING BLOCKCHAIN FOR AI.....	63
8.4	TECHNOLOGY ACCEPTANCE MODEL – TAM – FOR BLOCKCHAIN AND AI USE CASE	65
8.4.1	USEFULNESS OF THE SYSTEM	65
8.4.2	DIFFICULTY TO USE	65
8.4.3	ATTITUDE TOWARD USING THE TECHNOLOGY	66
8.4.4	BEHAVIOURAL INTENTION TO USE	66
8.4.5	ACTUAL SYSTEM USE.....	67
9.	<u>ANALYSIS</u>	<u>67</u>
9.1	BLOCKCHAIN THE CHOICE FOR HEALTHCARE	67
9.2	BLOCKCHAIN, THE TECHNOLOGY OF TRUST	68
9.3	ARTIFICIAL INTELLIGENCE, THE ARTIFICIAL HUMAN BRAIN	70
9.4	DEVELOPMENT OF NEW TECHNOLOGIES IN EMERGING COUNTRIES	72
9.5	CHALLENGES	72
9.6	FUTURE ADOPTION	73
9.7	DISCUSSION: A PHILOSOPHICAL PERCEPTION	73
	<u>CONCLUSION</u>	<u>76</u>
10.	<u>GENERAL CONCLUSION</u>	<u>76</u>
10.1	CONCLUSION.....	76
10.2	FUTURE DEVELOPMENT	78
10.3	CRITICAL PERSPECTIVE.....	78
10.4	LIMITATION	79
	<u>REFERENCES</u>	<u>80</u>
	<u>APPENDICES</u>	<u>89</u>

List of Tables

<i>Table 1: AI issues (From the author, 2020).....</i>	<i>14</i>
<i>Table 2: Benefits of blockchain (From the author, 2020).....</i>	<i>29</i>
<i>Table 3: AI issues with blockchain benefits – Solutions (From the author, 2020).....</i>	<i>39</i>
<i>Table 4: Participants.....</i>	<i>45</i>
<i>Table 5: Blockchain characteristics according to the respondents (from the author, 2020)</i> <i>.....</i>	<i>48</i>
<i>Table 6: Different type of blockchain – Explanation (from the author, 2020).....</i>	<i>52</i>
<i>Table 7: AI issues according to the respondents (from the author, 2020).....</i>	<i>53</i>
<i>Table 8: AI issues solved with blockchain - Respondents answers (from the author, 2020).....</i>	<i>56</i>
<i>Table 9: Opportunities and Difficulties while integrating Blockchain and AI in Emerging and Developed Countries (from the author, 2020).....</i>	<i>63</i>
<i>Table 10: Issues to integrate Blockchain with AI (from the author, 2020).....</i>	<i>64</i>

List of Figures

<i>Figure 1: Health care system performance in introducing digital health technologies rated by Physicians & Consumers (Ernst & Young, 2019).....</i>	<i>2</i>
<i>Figure 2: AI research studies around the world (McKinsey, 2020).....</i>	<i>4</i>
<i>Figure 3: Type of Artificial Intelligence (Strohm, 2018)</i>	<i>5</i>
<i>Figure 4: Use of data in Machine Learning (Jiang et Al., 2017)</i>	<i>6</i>
<i>Figure 5: Trustworthy AI throughout lifecycle (European Commission, 2020).....</i>	<i>9</i>
<i>Figure 6: Willingness to engage with AI in developed and emerging countries (PwC, 2017)</i> <i>.....</i>	<i>16</i>
<i>Figure 7: Hype Cycle for Blockchain (Gartner, 2019).....</i>	<i>20</i>
<i>Figure 8: Blockchain system (Arnold, 2017).....</i>	<i>23</i>
<i>Figure 9: Blockchain information system (Cleverence, Mussa, & Sam, 2018)</i>	<i>23</i>
<i>Figure 10: Blockchain for AI or AI for Blockchain (Dinh & Thai, 2018).....</i>	<i>33</i>
<i>Figure 11: Technology Acceptance Model (TAM) (Sauro, 2019).....</i>	<i>44</i>
<i>Figure 12: Which type of Blockchain in healthcare? (from the author, 2020).....</i>	<i>51</i>
<i>Figure 13: Where is it more difficult to implement those technologies? (from the author, 2020).....</i>	<i>63</i>
<i>Figure 14: Is the System Useful? (from the author, 2020).....</i>	<i>65</i>
<i>Figure 15: Is it difficult to use ? (from the author, 2020).....</i>	<i>65</i>
<i>Figure 16: Would you go for it? (from the author, 2020)</i>	<i>66</i>
<i>Figure 17: Is it Understandable and Clear? (from the author, 2020).....</i>	<i>66</i>
<i>Figure 18: What is your feeling? (from the author, 2020)</i>	<i>66</i>
<i>Figure 19: Is there a high probability AI and Blockchain are using together? (from the author, 2020).....</i>	<i>67</i>
<i>Figure 20: Does literacy need to be improved? (from the author, 2020).....</i>	<i>67</i>
<i>Figure 21: TAM Model for the Blockchain and AI use case (from the author,2020).....</i>	<i>73</i>
<i>Figure 22: Diseases using AI the most (Jiang et al.,2017).....</i>	<i>90</i>
<i>Figure 23: Sources of data in healthcare (Jiang et al.,2017).....</i>	<i>97</i>
<i>Figure 24: Business Value-add of Blockchain by 2030: \$3.1 Trillion (Gartner, 2019).....</i>	<i>97</i>
<i>Figure 25: Transaction between Bob and Alice (Zheng et al., 2018).....</i>	<i>98</i>
<i>Figure 26: The used protocol by different platforms (Salah et al., 2018).....</i>	<i>98</i>
<i>Figure 27: Blockchain's Benefits (Ali Siyal et al., 2019)</i>	<i>104</i>
<i>Figure 28: Blockchain's opportunities & Challenges (Ali Siyal et al., 2019).....</i>	<i>105</i>

<i>Figure 29: AI and blockchain together (from the author, 2020).....</i>	<i>107</i>
<i>Figure 30: Technology Acceptance Model (TAM) (Sauro, 2019).....</i>	<i>110</i>

Nomenclature

<i>AI</i>	<i>Artificial Intelligence</i>
<i>CNN</i>	<i>Convolutional Neural Network</i>
<i>DP</i>	<i>Deep Learning</i>
<i>EC</i>	<i>European Commission</i>
<i>EMR</i>	<i>Electronic Medical Record</i>
<i>GDP</i>	<i>Gross Domestic Product</i>
<i>GDPR</i>	<i>General Data Protection Regulation</i>
<i>IoT</i>	<i>Internet-of-Things</i>
<i>ML</i>	<i>Machine Learning</i>
<i>NLP</i>	<i>Natural Language Processing</i>
<i>PoS</i>	<i>Proof-of-Stake</i>
<i>PoW</i>	<i>Proof-of-Work</i>
<i>R&D</i>	<i>Research and development</i>
<i>WHO</i>	<i>World Health Organization</i>

Introduction

1.1 Context & Challenges

In the light of the current rapid digitalization of the world, new technologies emerge and sometimes so rapidly that the population or businesses do not have the time to accommodate and to adapt. Technological evolution does not stop, and the rhythm even accelerates (Bresnick, 2018). Indeed, today, it may seem unrealistic, but would we have thought that aviation would appear in the 18s (Moulinsard, 2020). That the 3D printer would allow us to create some physical materials within a short amount of time or that cars would be driverless? A lot of technologies emerge such as virtual reality or even smart devices. Companies which pass above those innovations will quickly find themselves overwhelmed if they do not react to those breakthroughs (Bresnick, 2018).

In addition, the increase of computing power and data generation have enhanced the development of technologies such as Artificial Intelligence (AI), blockchain or Internet-of-Things (IoT) (Niforos, 2019). AI is working with data as fuel and as the increase of the number of data generated is significant, AI development increases significantly (Koch, 2018). With all those breakthroughs, it will not be easy for humans to find their place against technologies and big computational power which will outweigh humanity in a lot of domains (Coucke, 2017). Based on this, the biggest inequalities will emerge according to Laurent Alexandre (2017) while Stephan Hawking (2018) revealed before dying that he was worried for humanity.

Moreover, AI, Telemedicine, Blockchain and other technologies are transforming and reshaping the way we interact in the health sector, the way data are shared or even how treatments and diagnostic decisions are taken (Reddy, 2020). However, the health sector faces some challenges and a major one is the fact of lagging behind in terms of technological adoption. Indeed, if we look at the healthcare sector, some figures may attract our attention. According to the WHO, 50% of the diagnoses or treatments are useless. According to another study, healthcare is lagging behind about a decade in comparison to other industries in adopting technologies. Indeed, 7% of healthcare companies have adopted digital transformation against 15% in other industries (Reddy, 2020). This result coincides with a survey conducted by the accounting firm, Ernst &

Young (EY) on 8, 500 consumers and 650 physicians in the US, Australia, UK and the Netherlands. It has been shown that the sector lags in implementing digital technologies as we can see in *Figure 1*. Indeed, EY declares that: « *Achieving a digitally driven health care system at scale is immensely complex, especially in an industry notoriously slow to change* ». However, due to the current COVID-19 epidemical situation, transition towards a more digital health system has been generated (UNCTAD, 2020).

Furthermore, it takes approximately 17 years for a technology to be implemented in the sector. Several reasons to this pacing problem are (Ernst & Young, 2019):

- Health sector is not instinctive with technological implementations;
- Health is a high regulatory environment where safety and quality need to be met for adopting a new technology such as data security at the expense of innovation;
- Standards and regulation;
- Cultural resistance to change as well as physicians and patients' education;
- Capital investment required.

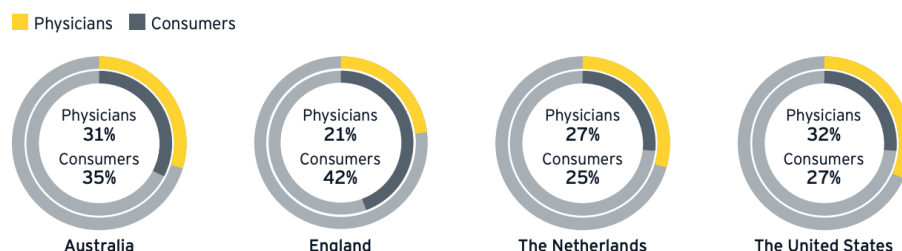


Figure 1: Health care system performance in introducing digital health technologies rated by Physicians & Consumers (Ernst & Young, 2019)

Without technological changes and restructuring, the current healthcare system will struggle to remain sustainable (McKinsey, 2020). However, even if digitalization will positively impact the healthcare outcome and even if there is a lot of enthusiasm and discovery in medical advances, it generates a lot of concerns and rising issues at the same time which can be difficult to overcome (Longoni, Bonezzi & Morewedge, 2019).

One of the disruptive technologies for healthcare, Artificial Intelligence, is a considerable transformative technology of our time. According to Ernst & Young (2019), AI will be at the centre of the healthcare system within the upcoming 10 years with for example AI-based diagnosis, imaging and analysis. The technology can drastically improve the quality of lives, wellbeing as well as the global health (European Commission, 2018). It can also

improve care outcomes, productivity and quality over the provided treatment. In addition, it can facilitate the practitioner's life by enabling him to spend more time with the patient thanks to AI's help (McKinsey, 2020).

However, some challenges have to be overcome to ensure that AI can be developed safely and responsibly. Indeed, today, the health industry faces ineffectiveness, in part, due to disparate data (Microsoft, 2018). On the other hand, the success of integrating AI in the society depends largely on the trust a user has in the technology. Therefore, as blockchain is known for being a trustworthy tool, these two promising technologies – AI and blockchain – for healthcare will be tackled in this thesis to see if blockchain could help to mitigate some of the AI issues.

1.2 Literature Review Methodology

This review presents Blockchain as well as the Artificial Intelligence technology, their way of working, their characteristics, some applications and their potential convergence. For the elaboration of this literature review, Google Scholar was first used by researching articles based on keywords such as: Blockchain, Artificial Intelligence, Machine Learning, AI issues, Convergence of Blockchain and AI, Blockchain for AI, Consensus Protocols, and others. Other sources were used such as books being either recommended by my supervisor or either selected on the university website and being available at the library. Other articles coming from scientific sources or published articles were also used.

In addition, as Blockchain is a nascent technology which is currently being explored and therefore subject to change in comprehension and explanation, the most recent articles were given a greater importance. The same logic applies to AI researches where however, exception applies as former definitions were used to understand the evolution of the technology.

Finally, the explanation of AI is first developed in order to understand what AI consists in, what the current existing applications are, followed by the issues and benefits the technology possesses. Then, Blockchain based on the same pattern as well as the convergence of the two technologies is presented. This order has been chosen with the goal of first understanding and presenting the issues – of AI – followed by the potential

solution – coming from Blockchain – to finish up with the integration of these two together to better understand where it comes from, how it can be used and why it exists.

1.3 Research question

This paper is an exploratory research regarding the disruptive technology of AI, Blockchain and the potential convergence of these two in the health sector. The research question is precisely: « *Can blockchain technology mitigate some of the perceived risks related to Artificial Intelligence? An exploratory research on ethical and technological issues in the healthcare sector* ». An important thing to point out is that looking for answers was not easy as the subject is nascent and relatively poorly explored.

Literature review

2. Artificial Intelligence

First of all, to understand the future impact of AI, important figures need to be quoted. By 2030, the global Gross Domestic Product (GDP) is expected to be impacted and to increase by \$15.7 trillion with the highest increase for China with a GDP increase of 26%. For North America, this contribution to the economy will reach 14.5% while the potential for the developed countries is still low as their adoption rate is low (Niforos, 2017).

In terms of development, investment is drastically increasing. By December 2019, the 50 largest investments reached up to \$8.5 billion from the private sector. Finally, in terms of research effort, China dominates it followed by the US and EU as we can see on Figure 2 (McKinsey, 2020).

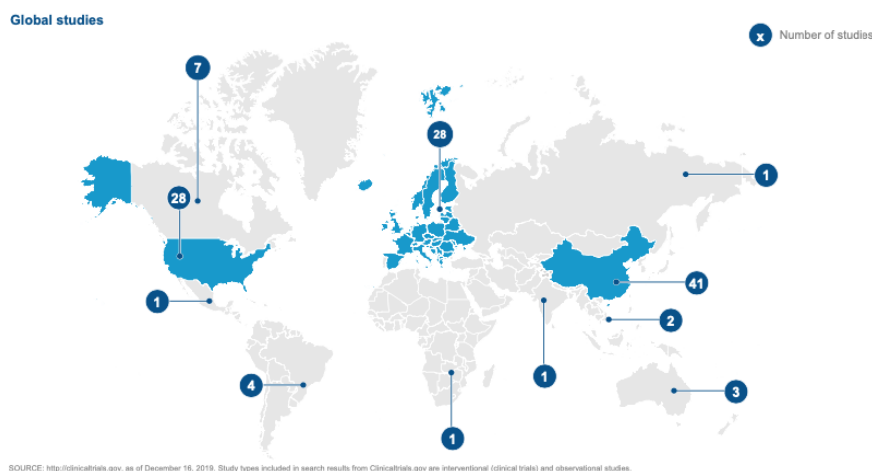


Figure 2: AI research studies around the world (McKinsey, 2020)

2.1 What is Artificial Intelligence?

2.1.1 Definition and apparition

Artificial Intelligence (AI) emerged in the 1940s-50s where the technology was considered as a machine allowing data storage with the goal of processing them at a high speed (Patterson, 1990). Even if it is still true, AI also gives the machine the ability to mimic human intelligence and cognitive functions by using logic, decision trees, relational rules and bases itself on experience (Jiang et Al., 2017). Ever since, AI has evolved and new applications in various industries are emerging.

According to Patterson (1990): « *AI is a branch of computer science (...) that exhibits some form of intelligence: systems that learn new concepts and tasks, that can understand a natural language or perceive and comprehend a visual scene, and that perform other type of feats that require human types of intelligence* ». For Plant (1994), AI allows the performance of actions which normally require the intelligence of a human brain to perform. To simplify, AI is composed of machine learning (ML) and Deep learning (DL), a subcategory of ML (Murphy, 2012) – *Figure 3*.

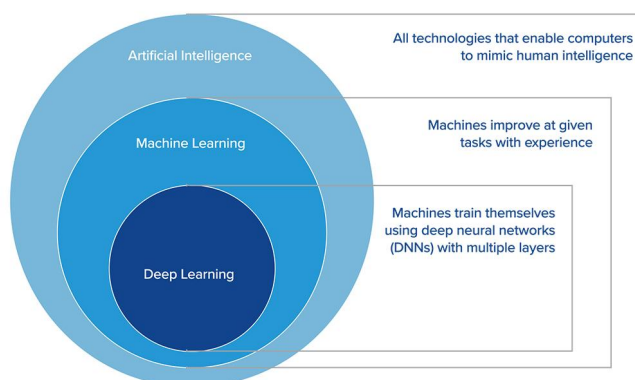


Figure 3: Type of Artificial Intelligence (Strohm, 2018)

2.1.2 Machine Learning, the AI for structured data

Machine Learning finds its application in accurate predictions as well as performance improvement with complex training samples such as data generated by humans. It can also create accurate algorithms, automate data analysis and detect unknown patterns from data (Murphy, 2012; Mohri, Rostamizadeh, & Talwalkar, 2018). Indeed, the more data the algorithm receives, the easier the analysis is, the better is the task performed and more accurate is the decision taken (Mohri, Rostamizadeh, & Talwalkar, 2018). Inputs for

the use of Machine Learning can be patient's traits – e.g. age, gender, disease, imaging, examination results – and medical outcomes – e.g. survival time (Jiang et Al., 2017).

However, different types of data exist. In the healthcare sector, the data generated are structured and unstructured. Structured data correspond to organized, easy to search and often quantitative data whereas unstructured data do not have predefined format and are often found under the form of qualitative data. Machine Learning analysis structured data such as imaging, genetic information and is therefore able to cluster patients' characteristics, to look for the probability of having a disease, to predict a treatment as well as the probability to succeed (Davenport & Kalakota, 2019). However, normal consultation such as physical examination and clinical laboratory results which provide unstructured data are also an important source of information. According to a PwC research, those data represent 80% of the total health data and accessing these types of information is not feasible for a human (PwC, 2017). They require conversion towards structured data to increase accuracy and analysis. As we can see on Figure 4, the unstructured data (e.g. clinical notes) are transformed into structured data to be then used in ML (Jiang et Al., 2017).

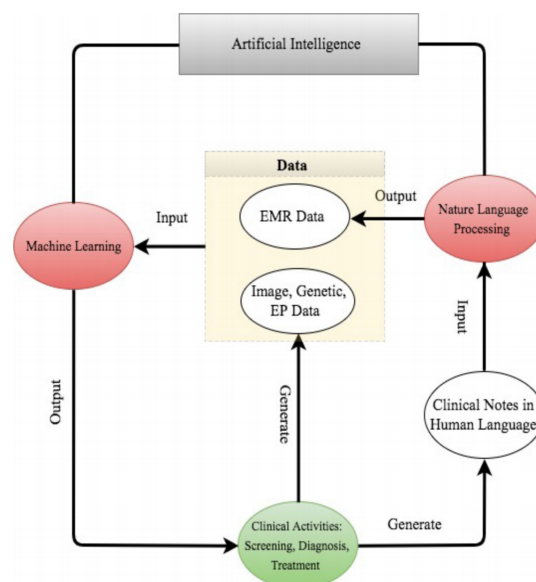


Figure 4: Use of data in Machine Learning (Jiang et Al., 2017)

In addition, ML is composed of unsupervised and supervised learning. While the first one is principally used for extraction, the supervised learning is used for predicting models by linking inputs such as patient's traits and outputs to learn a mapping (Murphy, 2012; Jiang et Al., 2017). As the supervised learning is more often used in healthcare, only this one will be tackled here (Jiang et Al., 2017).

2.1.2.1 Supervised learning

In supervised learning, the willing result is clearly defined. If we show cat images during the training, AI will be able to recognize cats after that (Coucke, 2017). Therefore, supervised learning selects the most appropriate result after several training sessions and provides more accurate results than unsupervised learning (Jiang et Al., 2017). The output may be categorized as nominal – e.g. income – or categorical – e.g. gender or real value – and therefore faces classification or pattern recognition problems (Murphy, 2012). Among the many existing applications, we will expose hereafter the robot, diagnosis and present the clinical assistant, stroke detection and medical Chabot in the *Appendix A & B*.

2.2 Healthcare digital transformation

2.2.1 Current AI discoveries

One of the first inventions of AI within the healthcare sector, the MYCIN, appeared in the 1970s at Stanford and was able to identify bacteria which was causing infections (Shortliffe, 1974). However, compared to those times, AI capability has improved and offers more opportunities than before. As it can be seen in the *Appendix C*, the three most important diseases identified using AI are neoplasm¹, nervous and cardiovascular diseases (Jiang et Al., 2017).

Thanks to ML, precision medicine, which is highly needed, is currently being improved. According to a PwC research, with its potential, AI will be more exploited by doctors to realize diagnoses and provide accurate analysis about a patient's health. Radiology and pathology will also be examined by an AI machine (Davenport & Kalakota, 2019).

2.2.1.1 Diagnosis

It has been shown, from an Australian study and confirmed by the European Institution that one out of twenty diagnoses are wrong. The process of establishing a diagnostic requires a doctor to put many data together and to solve a mathematical equation with multiple variables. This process is considered difficult and limited by the human cognitive functions. However, the computational power, speed and memory of AI make it easier for

¹ Neoplasm is a disease consisting of an abnormal growth and division of cells which create an important mass of tissue (Robertson, 2018)

the technology to detect and to establish a diagnosis. However, the quality of data is paramount as not adequate and secure data may bias the diagnosis (Coucke, 2017).

With the increasing research in Convolutional Neural Network² (CNN), processing imaging data to provide a diagnosis is no longer an issue and already exists for mammography (Dean & Ilvento, 2006; Rigby, 2019). Computer-aided diagnosis has been helping doctors to detect breast cancer for years (Rigby, 2019).

Another existing application which has been shown by Stanford University is the melanoma detection which is better detected by AI than by a dermatologist. In the future, you will be able to take a picture of your beauty mark and to have it analysed by an AI technology (Rigby, 2019). Indeed, AI is the opportunity to better catch risk profiles and predict the likelihood of a disease (Ilinca, 2020).

In the United states, the Food and Drug Administration (FDA) has already authorized AI to make a diagnosis over the diabetic Retinopathy³. IBM, the technology and consulting company has also made progress in diagnosing cancer. 99% of the diagnoses made by IBM Watson, an IBM designed computer system⁴, are in line with doctors' diagnosis until now. In addition, IBM also succeeded in identifying leukaemia (Jiang et Al., 2017). Finally, with the *cancerSEEK* technology, 8 cancers are detectable – breast, lung, liver, pancreas, ovary, stomach, oesophagus and colon – in a general and predictive way (Castellino, 2018).

2.2.1.2 Robotics

The range of existing robots goes from standard laboratory robots to surgical robots. The machine assistant system, *da Vinci* can do little invasive surgery, decrease blood loss, do small incisions and provide pain medications by itself. Robots are also used in hospitals for repetitive tasks (Estey, 2009). For example, RoBear is a robot-nurse able to take a patient out of bed and to put it back (PwC, 2017). Moreover, the world is experiencing a shortage of health professionals. In that context, assisting robots is a promising

² CNN is a sub category of deep learning able to do image recognition and classification such as identifying face, traffic signs or objects (Prabhu, 2018)

³ Diabetic Retinopathy is a secondary effect of diabet which affects eyes (Mayo Clinic, 2020)

⁴ IBM Watson is an AI tool launched in 2015 by IBM: « It was created to help solve some of the world most pressing health challenges through data, analytics and AI. By combining human experts with augmented intelligence, IBM Watson Health helps health professionals and researchers around the world translate data and knowledge into insights to make more-informed decisions about care in hundreds of hospitals and health organizations» (IBM, 2020).

technology for the assistance of people as well as needs identification especially in the ageing of the population (Salah et al, 2019).

2.2.2 Overcoming ethical and technological challenges

Even though these discoveries allow the development of new technologies and the improvement of medical outcomes, issues such as ethical concerns come up.

2.2.2.1 Ethical Issues

One of the major issues is the technology acceptance by doctors and users. Indeed, the adoption of a new technology often leads to a resistance from its potential users. It is difficult for people to trust a *black box* when making a decision. Indeed, AI machines have to be adapted for their duty to be in line with human morality and ethics. For now, ethics guidelines for AI in the health sector are lagging behind (Rigby, 2019). However, some guidelines have been created by the Organisation for Economic Co-Operation and Development (OECD) and the European Commission (EC). The EC, with 52 experts developed a framework focusing on the elaboration of ethics guidelines for the development of a trustworthy AI as well as recommendations in terms of policy and investment. These guidelines, as we can see on the *Appendix D*, focus on Human agency and oversight, technical robustness and safety, privacy and data governance, transparency, diversity, non-discrimination and fairness, societal and environmental wellbeing as well as accountability. Indeed, for AI progress in healthcare, the key challenges are privacy, governance, transparency, potential discrimination, lack of large data sets, high dimensionality and sensitivity.

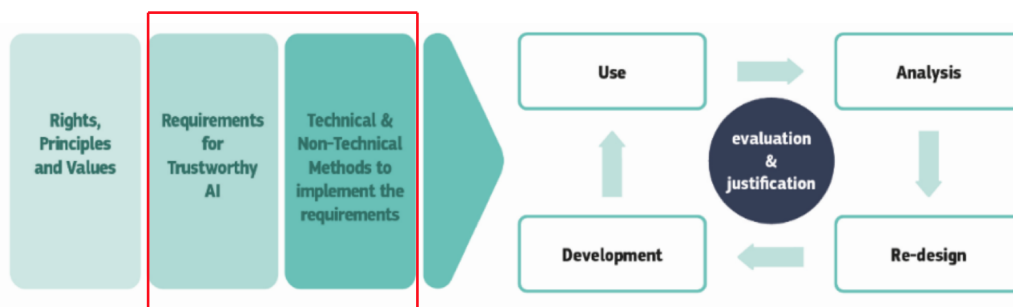


Figure 5: Trustworthy AI throughout lifecycle (European Commission, 2020)

Within this paper, the trustworthy aspect of AI, as shown in *Figure 5* will be tackled and the framework will be used for further analysis in the analytical part. The left part shows the steps through which you have to go in order to develop a trustworthy AI. The circular

aspect on the right part shows that assessing the AI ethical aspects needs to be done at each step of an AI product life cycle (European Commission, 2020).

Governance and legal

Even if AI will probably reduce human errors, what would happen if a medical malpractice occurs while using an AI technology? Who is responsible? It is a well-known problem and doctors are not able to provide any explanation about the use of the algorithm or to explain where the decision comes from, which can be a barrier for adoption and implementation of AI (Rigby, 2019). Responsibility and liability are not always clear, even less when AI delivers all the service by itself (Reddy et al., 2019). According to the EC, laws regarding AI do not exist at a national level. For now, the jurisdictions use general existing rules to deal with liability which may not be the best way of doing it (European Commission, 2019).

Indeed, as AI is a nascent technology and especially in the healthcare sector, a lack of standards can be noticed. The US FDA and the EMA - European Medicine Agency – two regulatory bodies, tried to regulate AI devices. Because of the high risk of medical devices, the FDA has made the requirements more stringent for medical device licensing. The developer of the device and algorithm must go through several steps which are costly and energy intensive to assess the AI machine before launching it. In addition, based on the policies developed by the FDA, manufacturers need to provide a prototype to the institution (Benjamins, Dhunoo, & Meskó, 2020). When a result is obtained, proof, evidence has to be used to assess the performance of the system before using it, and rules need to be defined (Jiang, 2017).

In addition, personal data can be accessed by many firms, and it has an important impact in terms of property rights and monetization over their use. Nowadays, consumers and individuals ask for more control over their own data. Indeed, if AI can help to make better decisions, it is better that the human who provided the data knows what has been done, who handled the data as well as their precise location. It has been shown that recognition of data property rights may help with an optimal mechanism as the consumer will be eager to find a right balance between privacy and the value, they can gather from selling his data (Niforos, 2019).

Trust

People who are concerned about new technologies, may be reluctant, and prefer to let more adventurous developers work on, before adopting any of the existing technologies (Bresnick, 2018). Indeed, the machine can calculate correlations, helps to detect symptoms, prevents diseases, gives personal treatments, anticipates secondary effects and takes the best decision. But, for that, the technology has to be trusted. According to a PwC research, only 55% of the population feels at ease with the fact of trusting a machine instead of a human while 38% does not feel confident about it (PwC, 2020).

According to another research conducted by Harvard, patients do not trust medical AI to treat them, even if the system has shown a better performance than doctors. One of the reasons for this fear is that patients think that they are unique and that an algorithm is not able to perform and detect personal diseases or anomalies (Longoni & Morewedge, 2019).

Potential Discrimination and biases

AI has been criticized for potential discrimination done by the algorithm. Indeed, Chen, Szolovits & Ghassemi (2019) affirmed that an algorithm does not provide accurate, fair and equal results across socioeconomic differences. For example, a study showed that a model which has been trained based on casual texts from the web presents stereotypes such as associating women with domestic words or hostile terms with African-American names (Schönberger, 2019).

Indeed, the issue known as *garbage in, garbage out*, reveals that if the fed data are biased, it will be reflected in the output. If data themselves do not reflect true information, biases may be encountered due to a lack of sample size disparity and the lack of data from a particular group. Minorities which do not have access to a health system, do not provide data, as no records for them exist. Therefore, they are immediately excluded from the AI development (Schönberger, 2019). Consequently, we have to ensure that AI inventions do not only improve health for young and urban people from western countries (Hart, 2017). That is the reason why the EC insists on the fact that the system cannot produce results based on biased or missing data. The data should be inclusive and represent different

population groups, as well as the more vulnerable ones – handicapped, ethnic minorities, children, women and others (European Commission, 2019).

Moreover, as current AI systems run on centralized models, some risks exist, such as data tampering, manipulation, doubts about the data provenance, as well as authenticity. That is why traceability and provenance of data are critical as it is, otherwise, holding back the development of AI technologies (Niforos, 2019).

Privacy, Data's accessibility and Cybersecurity

Most clinical data are not enough and operational to use AI, as we have seen with the explanation of unstructured data (Maddox, Rumsfeld, & Payne, 2018). Furthermore, data silos and data scattering make it more difficult to improve personal and global health, as interoperability is challenging and prevents R&D – Research and Development – improvement (Microsoft, 2018). Indeed, AI power is monopolized by big companies principally due to barriers for data accessibility, talents and computing resources (Dinh & Thai, 2018). For example, in November 2018, Microsoft France obtained the certification of storing health data. Consequently, other companies have to collaborate with Microsoft to have access to those data (PwC, 2020a).

This access is an issue that finds its cause in data privacy, as health data are priceless and personal, which makes that they have to be protected and stored in a secure place. However, data safety and privacy cannot be levelled down for the enhancement of a diagnosis quality (PwC, 2020a). The privacy of data's owner is becoming even more important, as the patient gathers his own information with, for instance, new smart health devices. To take a global figure outside the niche of the healthcare industry, 85% of the global consumers wish there were more companies to trust with their data, and 76% think that sharing their personal information with companies is evil (PwC, 2020b).

Therefore, gathering these data is difficult, as the health sharing data service needs to involve the patient in the sharing design, and not only developers or clinicians, as these data are private (Reddy et al., 2019). Using new models for data collection encouraging patients to share their data for research purposes is critical (Microsoft, 2018). Collecting quality data that are suitable for training AI is a technical problem. Knowing the

conditions and the environment in which the parameters – used for AI – are extracted is a drawback of the AI system.

Finally, it is important to not let the information in the hands of a third party and ensure security. Protection from cyber-attacks is paramount and especially in healthcare, as it can be deadly, and a threat to a patient's safety and data integrity. For example, if a cardiovascular simulator is hacked and an intentional retraining is done with the willingness to offer a bad drug to a patient, this patient could have complications (Iliashenko, Bikkulova, & Dubgorn, 2019).

Transparency and Explainability

As we have seen, the AI system is not trusted by users. However, they need to understand how the complex decision is taken by the machine to trust it (Reddy et al., 2019). Indeed, if a ML diagnostic system diagnoses a cancer based on imaging, the patient would like to know how the AI came up to this conclusion (Davenport & Kalakota, 2019). Therefore, AI needs to perform in a transparent way and to inform users about the potential harm it can cause, the limitation of the technology, what the patient can expect and how the decision has been taken to increase trust (Rigby, 2019). Tracing and knowing what the most important biomarkers are used for the diagnosis is also really helpful for doctors (McKinsey, 2020).

Indeed, understanding data's characteristics as well as the origin may help to understand a system's behaviour. Moreover, the General Data Protection Regulation (GDPR) in Europe requires that clear explanations for automated decisions are available to users (Microsoft, 2018). However, the complexity of an AI algorithm which analyses large data sets and variables makes it almost impossible to explain (Davenport & Kalakota, 2019).

AI issues	Privacy & Cybersecurity	Governance & Legal	Discrimination & Biases	Trust	Transparency	Explainability	Data accessibility	Data integrity, provenance and traceability
<i>In a nutshell</i>	- Protection from cyber-attacks is paramount as if attacks happen, it can result in harmful decision - Privacy of data is critical	- Responsibility and liability: who is responsible if something bad happens? - Lack of laws and regulations	- Algorithm does not provide accurate and equal results across socioeconomics differences - Minorities which do not have access to health system do not provide data and are immediately excluded from AI development - If the fed data are biased, it will be reflected in the output	- People do not really feel at ease with the fact of trusting a machine instead of a human	- AI needs to perform in a transparent way and inform users about potential harm	- AI algorithm analyses large dataset and variables which makes solutions difficult to explain. Understanding origin of a decision is important	- Not enough accessibility to data - Data owned by big companies - Access issues due to privacy as health data are priceless and private	- Difficult to obtain true data to trace the provenance, etc

Table 1: AI issues (From the author, 2020)

2.2.3 Advantages of trusting machine rather than human

AI does not only have drawbacks. It is a promising technology for healthcare and for overcoming the traditional medical market (Ilinca, 2020; Bresnick, 2018).

Trust and Efficiency

According to a large study conducted by PwC, gathering 11.086 respondents, rapidity (36%) and trust (33%) seem to be the most important characteristics in favour of AI implementation in the health sector. This can be contradictory with the previous results obtained. On the other hand, the lack of promiscuity (47%) and robots' capacity to take a decision (41%) are the principal factors of the unwillingness of AI and robots' adoption (PwC, 2017).

Showing the benefits of sharing personal data, what is being done with the data as well health outcomes improvement can help to increase trust (Microsoft, 2018). In addition, the development of smart health devices provides distance protocols and surveillance, such as the heartbeat condition and helps to provide the best treatment. Indeed, connected objects (IoT) may help the health sector by bringing the patient near to the doctor and sharing information between each other (Coucke, 2017).

Complexity

With the complexity of healthcare data such as the different variables used, it makes it difficult to create models. AI can help but, to be used in diagnosis, a high accuracy in data

is needed – where data come from a lot of different sources (e.g. diagnostic imaging, genetic and electro diagnosis in general – *Appendix E*). Therefore, AI can learn from similarities between information and improve the outcome (Jiang et al., 2017).

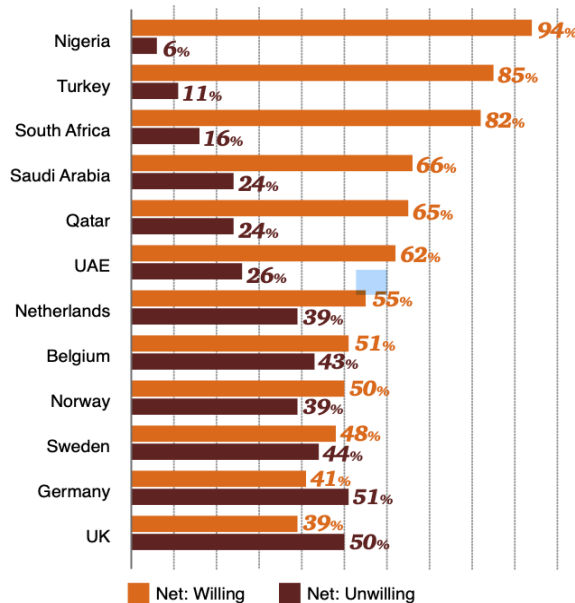
However, the collection and analysis of these data are also complex. For example, if your cardiac frequency is calculated during your run during winter or in an evening on your couch with a cup of tea, the result cannot be interpreted the same way. In addition, a doctor is not able to detect and analyse all that information from millions of data, to react immediately and accurately without the help of an AI machine as we just have said (Coucke, 2017).

Accuracy

Accuracy is an important benefit of AI. Professionals have difficulties to analyse all the existing data which may result in a wrong treatment, outcome or diagnosis. AI can face this problem by being able to analyse and treat a lot of data at the same time. It can therefore provide a more precise, clear and individual recommendation. Difficulty will also increase as we do not completely know the patient's medical history. An elderly person who takes a lot of drugs and where the doctor is not capable of evaluating his historical information may have difficulties to assess the potential existing synergies (Coucke, 2017).

2.2.4 Developed countries VS emerging countries

Figure 3: Percentage of respondents willing/unwilling to engage with AI and robotics for their healthcare needs (by country)



Source: PwC survey

Figure 6: Willingness to engage with AI in developed and emerging countries (PwC, 2017)

AI or other technologies emerge in developing countries as well. However, the transition may be different for several reasons. In developed countries, less people are trusting Artificial Intelligence than in the emerging ones as the current existing systems are already trusted by patients, strong and mature. Therefore, people from developed countries tend to not trust AI more than human. Which, with fewer strong infrastructures, emerging countries tend to follow and accept – See

Figure 6 (PwC, 2017).

Communities having a lower supply of healthcare services tend to have more willingness to trust and use an AI system than developed countries. As we can see in Figure 6, 94% of Nigerian consumers will be willing to engage with AI or robots in order to have answers about their health, diagnosis or even to recommend a treatment (PwC, 2017). The same 94% for Nigeria appeared in the YouGov survey in 2016 and it showed that this number reached 54% for Europe and the Middle East approximately. Regarding the health care cost, it can potentially be reduced and be lower than the traditional health system the emerging countries have.

Besides trust, gathering and having access to quality and structured data are some of the challenges. Finding a physician who provides good care in emerging countries is also difficult as well as having a good medical system and transparency in the quality of provided service. In addition, emerging markets are facing a lack of smart devices or AI-enabled tools which will be key for inclusion of technological solutions.

However, changes are already happening as an important phone penetration, as well as investments in digital health are going on. Even though the emerging countries would

gain benefits from the digital health transformation, and that the poorer community will benefit from those innovations, investments and major applications will take place in developed countries (Mrazek & O'Neill, 2020).

2.2.5 Conclusion and potential solutions

As developed earlier, physicians will face a considerable amount of data coming from a lot of different sources. In addition, trusting an algorithm, training them with secure data, and accessing these data are some of the issues encountered by AI. Moreover, explaining how a decision is taken by a *black box* is currently not possible, and may prevent the trust coming from end users. Targeting and developing solutions in emerging countries are needed in order to allow a wide scale development impact. To face this, data storage in a centralized and isolated institution may be overcome and delocalised.

In that context, the cloud could be a good idea, according to Philippe Coucke (2017). But, if we look at exchange security, a blockchain solution is needed. Indeed, this solution, as it will be tackled in the next part, affords information storage in a decentralized and shared way. Ilinca (2020) is on the same path and thinks that these challenges can be blown out by using blockchain. This is the same for Microsoft (2018) which thinks that blockchain could improve health information transfer, data exchange, improve patients experience, the service quality and reduce cost.

3. Blockchain and healthcare

Blockchain is a technology which increasingly erupts in our society and which could disrupt currently established business models. In the health sector, sensitive data and information are being exchanged, which makes blockchain helpful to secure and exchange them properly. For example, IBM Watson and the FDA want to share data with the goal of improving public health, and CDC – Centre for Disease Control & Prevention – chooses blockchain as a way of sharing information between organizations regarding epidemics. Indeed, blockchain can solve the interoperability issue existing in the health sector and has the potential to place the patient at the centre of the system, increase trust, security and privacy of health data which will be tackled in the next section.

3.1 What is blockchain

3.1.1 Definition

Not everyone may have heard about blockchain, but everyone may have heard about Bitcoin, a digital currency introduced by Nakamoto in 2008, which is working under the technology of blockchain, without the intervention of a third party – such as the bank – with the intention of increasing trust (Nakamoto, 2018).

According to Herweijer, Waughray, & Warren (2018) blockchain is: « *A new, decentralized and global computational infrastructure that could transform many existing processes. Its defining features are distributed and immutable ledger and advanced cryptography, which enable the transfer of a range of assets (...) whether it be money, goods, property, work or votes (...) among parties securely and inexpensively without third-party intermediaries* ».

In other words, the business world today, uses centralized systems or databases to make transactions or to store data. On the contrary, the new discussed technology is a decentralized database system where every party can access the database containing all the transactions or digital events which have occurred among those parties. The information available on the public ledger⁵ allows each participant to verify the transaction's information and a majority of people - called the miners⁶ - have to approve by consensus for a complete adoption of the new transaction. Thanks to this agreement, a transaction or stored data are secured, monitored, timestamped, transparent, tracked and accessible by every participant (Crosby and al., 2016). It will be tackled more deeply in the 3.2 section.

3.1.2 A brief history of Blockchain

It is in 2008 that everything about blockchain began when an anonymous person under the name of Satoshi Nakamoto wrote an article named “*Bitcoin: A Peer-To-Peer Electronic Cash System*” which explains a system where a transaction between two people happens without an intermediary – which its role is to validate and safeguard the transaction

⁵ Public record that keeps, maintains, secures participants' identity and the transactions executed between the network participants (Seth, 2020)

⁶ People, or node that donate their computer resources to solve the complex mathematical problem. The one who has found the solution is rewarded (Crosby and al., 2016)

(Nakamoto, 2014). The bitcoin cryptocurrency is the starting point of this invention. After the paper, in October 2008, the open source program to which everyone could have access was released (Herweijer, Waughray, & Warren, 2018). The 3rd January 2009, the first block was created, and the first transaction occurred on the 12th of January 2009 and started with a release of 50 coins (Leloup, 2017). In July 2018, the market capitalization of cryptocurrency stood at about \$254.67 billion (Herweijer, Waughray, & Warren, 2018).

The second breakthrough has been the apparition of blockchain within other sectors such as the automotive, logistic, media, politics or even the health sector (Coucke, 2017; Herweijer, Waughray, & Warren, 2018).

The third innovation, the smart contract embodied on the Ethereum system allows to create little computer programs and decentralized applications (Gupta, 2017). Indeed, at the beginning, blockchain technology was created only for money transactions. Therefore, Vitalik Buterin has created a different blockchain which could support different types of applications, Ethereum (Leloup, 2017). In 2013, he proposed an open-source platform able to use the functionality of smart contracts on a permission-less network (Bragagnolo et al., 2017). It is currently the largest Blockchain protocol containing 17 000 nodes, 250 000 developers and 87% of the 800 existing cryptocurrencies (Ilinca, 2020).

The fourth innovation is the Proof-of-Stake (PoS) – a consensus protocol explained in the *Appendix J*. Finally, the forthcoming fifth innovation is the scalability of blockchain. In other words, the increase of the capacity of blockchain (Gupta, 2017).

3.1.3 The business impacts

Even though the technology is at its beginning and that the health sector is a late adaptor, some applications can already be seen. In the future, the rise of the technology will have a considerable impact. Marc Andreessen, the dean of Silicon Valley's capitalists, has described Blockchain as the most promising invention since the internet (Crosby and al., 2016; Gupta, 2017). Johann Palychata, function at BNP Paribas, explained that the software which allows the digital currency to operate can be considered, and compared to the invention of the combustion engine, and will potentially transform the way the world is behaving (Crosby and al., 2016).

Moreover, according to a study done by EFMA (European Financial Management Association) and Deloitte, 58% of the financial institutions think that their job and their value chain will be impacted with blockchain. 53% of them think that blockchain will be common by 2 to 5 year, 20% by 18 months to 2 years and 11% by 12 to 18 months (Loignon, 2017).

In addition, as blockchain is currently gaining importance and that people and businesses start seeing the advantages of the technology, businesses, and more especially start-ups, investors, speculators and entrepreneurs have begun to invest in the technology. According to a Gartner study, 3.1 trillion dollars of investment is expected over a 10-year horizon (Granetto et al., 2017) – *Appendix F*. Another study depicts that blockchain in healthcare will reach the technological plateau in more than 10 years (Gartner, 2019).

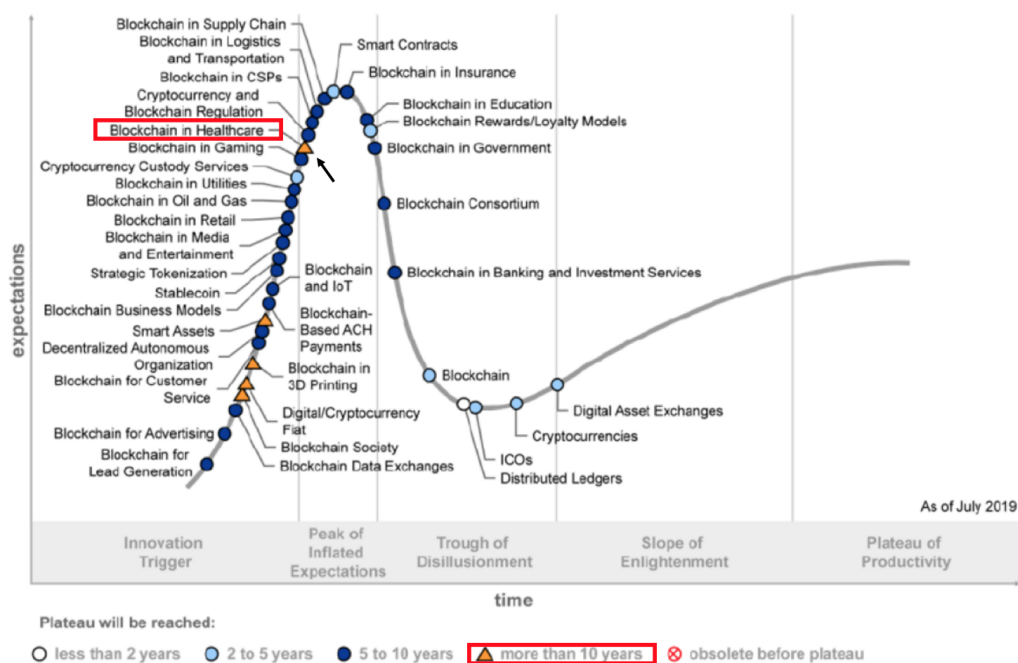


Figure 7: Hype Cycle for Blockchain (Gartner, 2019)

3.2 The technology behind blockchain

3.2.1 How does blockchain work?

Organizations need and want some characteristics to outperform such as data integrity, equal rights and trust. These characteristics can be provided by the cryptographic system which ensures the data integrity and trust, while the Peer-to-Peer (P2P) network ensures the equal rights to make and update transactions (Ali Syed, et al., 2019).

3.2.1.1 The decentralization

Today, trust in authority is at the centre of the system, as it is decentralized. The drawbacks of this long-used method are the information altering, database updating, hacking, deleting, ethical issues such as data integrity, access to resources, immutability, transparency and trust (Ali Syed, et al., 2019; Haidar et al., 2018).

With blockchain, the authority belongs to everyone in the case of a public blockchain, and to the authorized nodes in the case of a private blockchain; and does not compromise the individual privacy (Xu et al., 2016). Indeed, transactions can be verified at every moment and at every stage. That is why blockchain may improve data analytics, data storage and therefore, data management by improving the quality of the data and the way they are used (Ali, 2018).

Moreover, if the system crashes, or if a failure occurs, information will still be accessible as everyone has a copy (Benet, 2014; Ali Syed et al., 2019). However, the initial information is not stored. It is a reference which exists on the blockchain, and data is *off-chain*. It allows the system to use less volume which, if data are stored *on-chain*, can be really expensive as storing large size information may be expensive, due to the size limit available per block – for bitcoin, it is limited to 1 megabyte (Benet, 2014; Loignon, 2017).

3.2.1.2 Smart Contract

A smart contract is a computer program that, once the conditions of an established contract are met, the action previously required occurs, reacts accordingly and automatically (Crosby and al., 2016; Ali Syed, et al., 2019). For example, when a patient leaves hospital after being discharged, a follow-up is not always respected, and medical errors happen. With a smart contract, notifications and reminders can be sent to the patient, to follow any process automatically. In addition, a smart contract could gather information for compliance. If a breach is found, the smart contract would automatically inform the third party (Ilinca, 2020). Moreover, if the authorization from a patient is being requested and the patient allows the use of his data, an automated unlock of the patient's information is immediately performed (Ilinca, 2020).

Finally, Smart contracts could help patients to have more control over their data and to monetize them. For example, it can be used for charging pharmaceutical companies for accessing and using patients' data for research.

3.2.1.3 The technical aspect of blockchain

Before using the smart contract and benefiting from blockchain's advantages, understanding the system is paramount. To use this system (Crosby et al., 2016, Leloup, 2017):

1. The user has first to create an account and connect himself to find other computers.
2. Once connected, he receives an address which is similar to a bank account number.
3. When a transaction occurs, this one is signed by a digital signature of the sender with his private key and is sent to the public key of the receiver.
4. If the sender wants to use the available information, he must prove his ownership of the private key. Then, the receiver verifies the digital signature by using the public key of the sender.
5. After the verification, the transaction is registered, broadcasted to every node and recorded in the ledger. When the signed transaction is spread over the network, the other users can access it via the public key, which will help with the decryption – *Figure 8*.
6. The majority of the network has to know and approve the historic of every transaction of every node. If a transaction is unconfirmed by the validator, it will not be added to the chain.
7. When every node is in agreement, the new blockchain is created. If several blockchains are generated, the longest one is kept.

The signature (3) is composed of 2 phases. The encryption based on the private key, which corresponds to the signing phase and the decryption based on the public key, which corresponds to the verification phase. *Figure 8* below illustrates well how a transaction is broadcasted and validated to then be added to the blockchain. An illustration and explanation with Alice and Bob are available in the *Appendix G*.

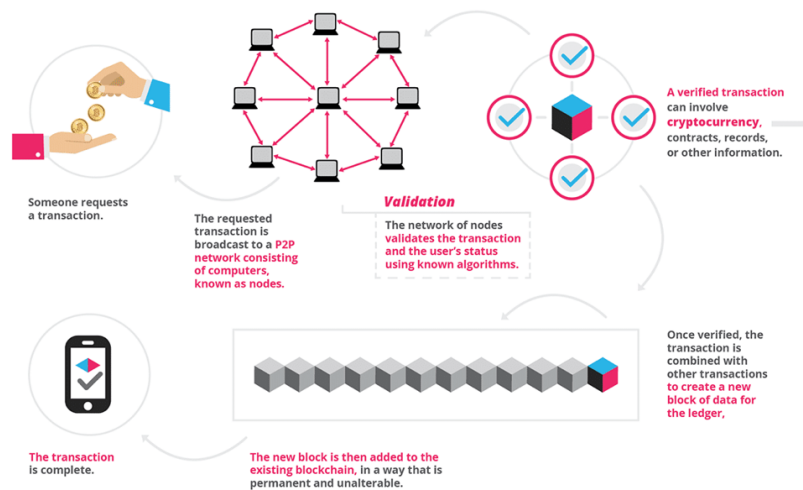


Figure 8: Blockchain system (Arnold, 2017)

However, once a transaction occurs, it is not necessarily classified by the transaction time occurrence. Due to the fact a transaction is sent to every node of the peer-to-peer network, the transaction does not register in order. The blockchain technology system solves this problem. Indeed, it links blocks through a chain in a chronological order.

In addition, to avoid any hacking, every block – *Parent block* – is composed of a hash – *Hash of block $n-1$* – which corresponds to a code composed of letters and figures, and which point to the previous block – *Figure 9* (Crosby et al., 2016; Herweijer, Waughray, & Warren, 2018). The maximum number of transactions a block can register depends on the size of the block. as well as the size of each transaction (Zheng et al., 2018).

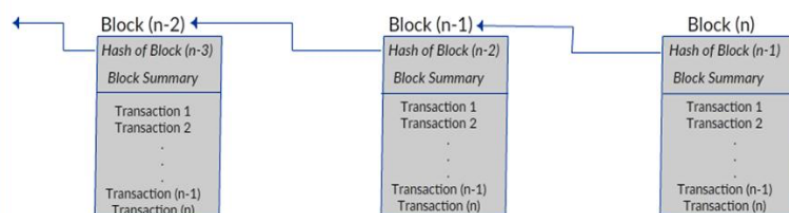


Figure 9: Blockchain information system (Cleverence, Mussa, & Sam, 2018)

3.2.1.4 Consensus models

To register and synchronise the transaction in a block, a distributed verification process, a consensus protocol mechanism is needed. According to Salah et al (2018) and as we can see on the *Appendix H*, the two most used consensus models are the Proof-of-Work (PoW) and the Proof-of-Stake (PoS) – *Appendix I & J*. Other mining processes exist, such as Proof-of-Authority, which is a mix between PoS and PoW, but it is out of scope in this paper.

Nevertheless, as different consensus protocols exist, and as their usage depends on the specific use case – for example, bitcoin uses PoW which has a high level of energy consumption –, we have not found any information about the mechanism used in healthcare specifically. That is why the existing protocols are not explained. However, determining the optimal mechanism to retrieve near-real-time information in healthcare is important. Therefore, the selected protocol must be well chosen and avoid latency (Brodersen, et al., 2016).

However, even with this consensus mechanism, as we will see, the system can still encounter attacks although it is still less plausible with blockchain, than in traditional systems (Rosic, 2020).

3.2.1.5 Different type of blockchain

Different types of blockchain – *Private, Public or Hybrid* – exist and are used for different situations (Zheng et al., 2018). Only the *private* and the *public* blockchain will be tackled in the subsection, as the *hybrid* blockchain is a mix of the two previous ones.

Private and Consortium Blockchain

In the private blockchain, the system is managed by one organization and not everyone has access to the system (Kwon, 2014; Cachin, Sorniotti, & Weigold, 2016). Consequently, less attacks are possible (Ali Syed, et al., 2019). Indeed, an institution or someone in charge of the blockchain gives access to the different participants, which makes the transaction faster (Salah et al., 2018; Zheng et al., 2018). Therefore, as the final decision can be taken by the organization, it means that the blockchain is partially centralized. It also means that the person in charge can alter or modify a transaction regarding his needs and reduce security (Zheng et al., 2018). However, according to the EU, private blockchain can be better for the implementation and respect of the GDPR as privacy is increased with this type of blockchain (Niforos, 2019).

The consortium is similar to the private blockchain. However, the main difference is that the consortium blockchain is managed by a group of organizations (Salah et al., 2018).

Public Blockchain

The public blockchain is a public ledger, which is distributed on the whole network, whereas the copy is seemingly to every node, and where all participants can join, read, write and participate to the consensus (Salah et al., 2018; Zheng et al., 2018; Becker et al., 2013). The system is therefore more likely to be victim of a malicious attack, due to its openness (Ali Syed, et al., 2019). This attack happens generally if 51% of the network is detained by the hacker. However, identities are anonymous and use pseudonymous data (Salah et al., 2018).

Public VS Private blockchain

According to a study, 53% of financial institutions say that the private blockchain will allow a broad adoption of the blockchain technology while 11% think that the public blockchain will be more used (Loignon, 2017). According to Zhen et al. (2018), this is the opposite, the public blockchain is and will be the most used one. To show a broader use case, companies are also adopting the hybrid approach. 40% are working with a permissioned blockchain, while 34% are using a permissionless and 26% a hybrid system (PwC, 2018).

Regarding challenges, privacy and security can be a drawback for both systems (Ali Syed, et al., 2019). In addition, as we can see with bitcoin which uses a public blockchain, the technology can only manage 7-8 transactions per second which explain the latency of the system. For the healthcare sector which cannot afford that latency due to the fact they have a huge amount of transactions which can be critical for a patient's health, public blockchain may not be the best option. In consequence, in the healthcare sector, organizations piloting blockchain technology bet more on the private blockchain as they ensure to only invite trusted participants. The opposite may be really compromising in that kind of institution (Bresnick, 2018; Reddy et al., 2019). However, according to other sources such as blockchain council, the public blockchain can be more secure as there are more participants and an active participation from them can prevent malicious attacks as it is more difficult for a majority of the nodes to gain the 51% control (Sharma, 2019).

3.3 Blockchain's characteristics

After blockchain technology emerged in the health sector, the ONC-HIT (Office of the National Coordinator for Health Information Technology in the US) created an organization about blockchain and its potential development in the sector. The health management, screening processes, drug distribution, clinical trials, security of personal medical data may be enhanced and more secure than before (Seong-Kyu & Jun-Ho, 2020).

3.3.1 Blockchain implementation in healthcare

Implementing blockchain may not be the right solution for every situation. According to a study conducted by Deloitte, it emerges that to implement a blockchain project, some characteristics are better met before doing it. These are:

1. The participation of several parties generating transactions;
2. The trusting aspect in the added transaction;
3. The fact that intermediaries are not trusted;
4. The security.

All these conditions are required for a successful implementation of Blockchain in health sector (Ilinca 2020).

3.3.2 Benefits of blockchain

The distributed computing system provides trust, security, transparency, privacy, data integrity, immutability and time-stamped information (Ali Syed, et al., 2019; Coucke, 2017). Here, Immutability, Anonymity & Privacy, Auditability, Integrity, Security & Transparency as well as Decentralization will be tackled.

Immutability

The technology is a reliable, shareable ledger of transactions which provides information with less errors and best traceability (Herweijer, Waughray, & Warren, 2018). If you try to change something in the previous block, you need to change all the following blocks due to the hash function (Sharma, 2019; Leloup, 2017). In addition, if the record is tampered, falsification can easily be detected and invalidated as blocks are being verified by the network through a consensus (Zheng et al., 2018; Ali Syed et al., 2019). Therefore, if something wrong is written, the information will only be registered in the person's book and not in the public ledger (Loignon, 2017).

Immutability makes it useful for storage of critical data where accuracy and auditability are critical for the healthcare sector (Ilinca, 2020; Suliman et al., 2018). It is beneficial within healthcare as hacking a node is difficult and the compromised node may be kicked out of the network without interrupting the operation as data are replicated to every node (Ilinca, 2020).

Anonymity and Privacy

The technology improves anonymity as it does not provide any information on the user or on the stored information (Herweijer, Waughray, & Warren, 2018; Ali Syed, 2019). Indeed, users remain anonymous and interact with an address which prevents them from giving their identity (Zheng et al., 2018). It is helpful in the healthcare sector where a lot of stakeholders such as doctors, patients, insurance companies, health organizations and governments exchange information (Ali Syed, 2019). Moreover, as we have seen earlier, the population and patients can own, control their own particular data and do not belong to big companies anymore or institutions such as hospitals (Zheng et al., 2018).

Auditability & Integrity

Blockchain is subject to audit verification as it is a decentralized network where each transaction is monitored and where the consensus helps to reach an agreement (Zheng et al., 2018). Thanks to the audit aspect, immutability and compliance which are important in healthcare are easy and less expensive to report as it goes faster (Ilinca, 2020).

In addition, healthcare is a sensitive sector in which data integrity is critical. If an error occurs during exchange or data storage, it can alter prescription, laboratory test and operation as they are based on patient's records (Ali Syed, 2019). Moreover, healthcare data are shared with a lot of parties such as providers, patients, pharmacists, doctors and data integrity are highly important as patients' lives are put at risk (Ilinca, 2020).

Security and Transparency

Blockchain offers lower risk as it allows a better visibility, less exposure, less fraud and provides a more accessible platform for users. Moreover, the transaction is stored in a ledger which increases transparency and security while removing a central authority increases trust (Suliman et al., 2018; Herweijer, Waughray, & Warren, 2018). However, if

the data entering the blockchain is itself untrue or inaccurate, the user can inadvertently put his trust into a false information (Kemp, 2020).

Moreover, security is an important topic as patients' health data are sensitive, private and may be one of the most precious data we may have. Thanks to the blockchain technology, the transaction is protected with the decentralized monitoring and the hash function (Leloup, 2017). The connected aspect of blocks by the hash function makes it safe, ensures the integrity of transaction and prevents its manipulation (Ali Syed, et al., 2019). As the technology does not allow us to go back and forth, the only way to store data is in an irreversible way. In case the public blockchain is chosen, it is difficult to change the ledger. In that case, a person, a node or a group would need to own 51% of the system to alter it (Herweijer, Waughray, & Warren, 2018).

Regarding the GDPR, it can be vulnerable as the technology does not afford any changes (Seong-Kyu & Jun-Ho, 2020). Indeed, the hash function in the block would need to be altered – and this for every following block – which could be really energy and time consuming and difficult to do (Herweijer, Waughray, & Warren, 2018). However, the Art.17 of the GDPR exposes the right of a person to ask for his personal data to be erased without a delay and under certain conditions that we can find in the *Appendix K* (European Parliament, 2016).

Decentralization improve cost saving

Thanks to decentralization and no need of a server setup, direct or indirect cost may be saved as no intermediaries exist anymore (Zheng et al., 2018; Herweijer, Waughray, & Warren, 2018). Indeed, new operating models can be more efficient while removing brokers, administrative costs or also transaction costs (Vector, 2018). According to Diego Espinosa, the CEO of Healthcoin, using blockchain could help to reduce these costs by connecting stakeholders with important data without requiring an expensive layer of data, a middle management as well as data-sharing system (Engelhardt, 2017).

<i>Blockchain benefits</i>	<i>Immutability</i>	<i>Privacy</i>	<i>Anonymity</i>	<i>Auditability</i>	<i>Integrity of data</i>	<i>Security</i>	<i>Transparency & Traceability</i>
<i>In a nutshell</i>	- Blockchain is immutable, if you try to change a transaction in the block, you need to change the hash function of the previous block. - If the network is tampered, falsification can easily be detected as blocks are being verified by the network	- The technology does not provide any information on the information stored.	- Users remain anonymous and interact with an address which prevents them from giving their identity.	- Blockchain is subject to audit verification as it is a decentralized network where each transaction is monitored	- The integrity of data is ensured as the system cannot be tampered	- Blockchain offers lower risk as it allows a better visibility, less exposure, less fraud, and provides a more accessible platform for user	- The transaction is stored in a ledger which increases transparency - Information can be traced back

Table 2: Benefits of blockchain (From the author, 2020)

3.3.3 Drawbacks of blockchain

As we have seen with Mougayar (2016), the development of the network is still to be analysed and enhanced, which is why some technological challenges and other limitations may occur. The ability to overcome them will determine the success of blockchain in the coming years. Indeed, blockchain faces technological, scalability, sustainable, security, interoperability, legal and regulatory challenges (Herweijer, Waghraay, & Warren, 2018).

Technological aspect

First, blockchain faces an underdeveloped ecosystem infrastructure as the infrastructure is still too fragile. Each blockchain needs its own infrastructure and a good ecosystem including middleware and software applications. Lawyers, developers, solutions and service providers are also needed. This difficulty may come from the scarcity in terms of developers as not enough professionals are available.

Scalability

Today, technologies such as bitcoin or Ethereum can only process between 3 and 30 transactions per second while Visa allows 60 000 transactions. Indeed, the size of the network is limited, and it is important to find alternatives to maintain trust and increase the size of the network as the number of users increases (Herweijer, Waghraay, & Warren, 2018). The space limitation may prevent from the storing of medical data as they are relatively complex and vast in volume (Seong-Kyu & Jun-Ho, 2020). These data coming

from patient's records, test reports, X Rays, MRI scans, or other tools need to be registered. In consequence, as it is not scalable and with the increase and growth of available data, the speed of recording and accessing the data decreases (Ali Siyal et al., 2019). However, if a larger storage space is used, blockchain may be slower. Therefore, a trade-off between security and the size of the block is a challenge for the technology (Zheng et al., 2018).

Energy Consumption

Energy consumption is an important drawback of blockchain. For example, PoW is really energy intensive which is negative for the environment. That is why developers are working on other systems that would be eco-friendlier. In 2018, bitcoin technology, which uses the PoW, had a consumption of 70 terawatt hours per year. To represent it more clearly, it is equal to Austria's energy consumption and will be equal to Denmark's consumption in 2020 (Loignon, 2017). A single bitcoin transaction could provide the energy to 1.5 US homes for a day. As the PoW is not especially the consensus protocol used in healthcare, more explanations about it can be found in the *Appendix I*.

As we have seen in the consensus part, the consensus protocol mechanism used is dependent on every activity. According to Ghosh & Das (2019): « *Switching to other protocols like PoS or Proof-of-Authority can help in reducing the energy consumption for validating blocks or transactions* ». Using renewable energy may also be an option as it can avoid polluting the environment and not increasing the carbon footprint.

System complexity and user adoption

Most users cannot handle the complexity of the system (Mougayar, 2016). As it is a new technology, people and businesses may be sceptical about it and blockchain will need to gain industry and users adoption. It takes time to adapt to new changes, to trust and rely on new technologies and in the fact they are safe, secure and complete (Crosby et al., 2016). That is also why the usability of the technology is unknown from the population and may be laborious to be integrated. However, in the future, everyone will use a system using blockchain without knowing it (Leloup, 2017).

Indeed, every emerging technology faces adaptation time and acceptance of the challenges the technology faces as seen in the drawbacks section (PwC, 2018). In addition,

companies which will implement blockchain will have to put money into it as it will bear additional cost and innovation dilemmas at the beginning (Mougayar, 2016). Furthermore, education will play a crucial role as executives may have a lack of understanding and it may prevent them seeing the full value and vision of the new implemented technology. They can also be reluctant due to the change management and the fact of trusting computers consensus instead of a known third party. Therefore, blockchain literacy is needed (PwC, 2020a).

Security risk

Although we have seen security as a benefit of blockchain, it encounters some risk. That is why, blockchain uses three basic concepts: hashing, keys and digital signatures (Mougayar, 2016). Indeed, a public and private key are needed to exchange data and ensure that data is safe. However, if a hacker finds the right combination of public and private key, he may access the data, which is possible but difficult. However, with the enhancement of computing power, it may become easier to crack the system. A solution to this unwilling situation would be that the keys become stronger in the future (Crosby et al., 2016). Therefore, users have to pay attention to their keys, store them and process them securely. Finally, as blockchain is slow, a trade-off between security and efficiency may reduce security (Niforos, 2019).

Lack of standards & interoperability

Another challenge is the lack of standards for the technology. Indeed, standardisation could facilitate the transfer of medical data among institutions even if they are different. Indeed, the integration of blockchain with other IT systems is paramount. Standards which are limited at the moment would need to be created as we need to optimise the interoperability between the different platforms (Herweijer, Waughray, & Warren, 2018). According to Leanne Kemp (2020), CEO of Everledger, « *leaving blockchain unregulated, at the whim of the open market, would prove counterproductive* ». In addition, moving every documentation, contract and other digital event into the new blockchain based methodology can take time and be costly (Crosby et al., 2016).

Legal limitation

The biggest uncertainty about blockchain is the rules and legal aspect more than security nowadays (Loignon, 2017). Smart contracts will need to be proofed immutable and recognized by the law to be valid and enforceable. Now, if a problem occurs, who is responsible as it is a shared ledger? Legal system will need to clarify accountability and responsibility. However, regulations for decentralized entities are more difficult than for central ones (Herweijer, Waughray, & Warren, 2018).

Compliance may also encounter difficulties as permitting P2P counterparty validation or allowing the link to smart contracts may be difficult to obtain. Moreover, these jurisdictions need to be applicable globally as the technology will allow transactions all around the world. For now, jurisdiction is defined by each country and it may limit the transfer and access to data between stakeholders due to the privacy and regulation issues (Ali Syed, 2019). So which jurisdiction needs to be applied? Countries have to move as the one which takes the market share at the beginning will impose their rules (Herweijer, Waughray, & Warren, 2018).

3.3.4 Some application

Medical trials and drugs traceability applications are presented hereafter. Patient's record and monitoring examples are available in the *Appendix L, M*.

3.3.4.1 Medical Trials

Putting all the steps in a public ledger would help to not lose information and to have authentic steps of every trial. Therefore, institutions will be able to ensure that no falsifications occurred by researchers (Leloup, 2017). For example, in a trial, the research centre does the test, the laboratory orders them, the health authority authorises them and everything will be registered on blockchain. Using this technology will also help to take the responsibility of anyone as we exactly know who did what, how and when (Loignon, 2017).

In addition, every trial requires the consent of its participants. Blockchain could timestamp and register the steps toward this consent while being able to trace it and being accessible by authority or candidates. Thanks to smart contracts, it could also send notifications to patients about a change in the protocol and ask for new consent.

3.3.4.2 Drugs traceability

In developing countries, 10% to 30% of the medications are fake. The WHO estimates 700 000 deaths due to these fake drugs (Leloup, 2017). Blockchain will help to trace drugs as well as the required temperature needed for drugs during their transportation and storage phase between different stakeholders and to increase the quality control process (Ali Syed, 2019; Ilinca, 2020). In addition, the batch can be scanned at every stage to the pharmacy shelf and traced back in case of an issue (Ilinca, 2020).

As it is resumed in the *Appendix N & O*, we know the blockchain's benefits and we have seen Artificial Intelligence's drawbacks. Based on this, could the system of blockchain help AI to face trust, biases and other challenges?

4. Artificial Intelligence and Blockchain as working together

As Woods (2018) affirms, blockchain and AI can reduce the security threats faced with the increase of an internet-based world where robots interact together more often as well as human-bots. Moreover, handling exponential volume of data and people's acceptance of AI based caregiver increases and is therefore the priority of AI developers in ML.

As we can see on Figure 10, only the blockchain for AI will be addressed as tackling AI for Blockchain as well may be too long for only one paper.

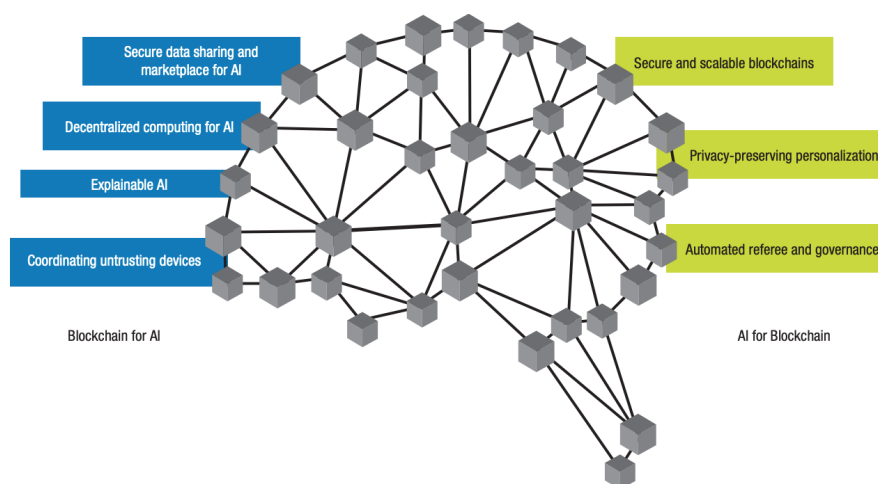


Figure 10: Blockchain for AI or AI for Blockchain (Dinh & Thai, 2018)

4.1 Blockchain and AI future together

4.1.1 Blockchain and AI in the healthcare sector

As we have seen, AI and blockchain have great potential in the healthcare sector. AI is needed as it will help to create new services and health businesses will be able to make better diagnosis, have a better understanding of genetic information as well as analysis. Less errors may occur, diseases will be monitored and prevented. Diagnosis will be possible thanks to the computer itself after analysing a patient's medical image, medical charts and other reliable information. However, with the sensitivity of the healthcare personal data, blockchain is more than welcome as it is immutable, time-stamped and almost impossible for information to be leaked (Seong-Kyu & Jun-Ho, 2020).

4.1.2 Can blockchain help AI?

As we have seen in the AI part, this technology has a great potential, but is subject to biases threats due to data usage – from discrimination due to the sample used to data manipulation – as well as attacks which results in bad decision (Chen et al., 2019). According to Salah et al. (2018), even if blockchain and AI are not concretely integrated together yet, a big potential in integrating them cannot be avoided as it may help to outweigh some of the potential cited issues in the previous part. Indeed, bringing these two together may lead to important breakthroughs and enhance the healthcare system around the world (Bresnick, 2018). It can (Marwala & Xing, 2018; Panarello et al., 2018; Salah et al., 2018; Niforos, 2019):

1. Enhance AI explainability as we can trace AI decisions;
2. Help to register data created with training, but also the data available before and after the AI training;
3. Provide quality data generated by AI. ML works better with accurate, reliable, stable, and trusted data to provide a good final decision which can be provided thanks to blockchain. Indeed, this technology relies on integrity and resiliency as information is cryptographically signed and approved by every actor. It can also help with biases, trustworthiness and attacks. According to a study done by IBM and the Ponemon Institute, a data breach in the US costs on average \$3.9 million to the hacked company.
4. Improve decision making by creating decentralized AI and algorithms.

As Banafa (2019) explains, those technologies are relating to data in different ways and it makes sense to use them together for the exploitation of data in a new way.

4.1.3 Advantages and significant features for Artificial intelligence based blockchain

4.1.3.1 Decentralized VS Centralized

The major difference between AI and Blockchain is power. AI is a centralized technology relying on data which are owned by powerful companies having resources to invest in. These companies enrich themselves, get the most out of AI and make sure that the poor will not be able to benefit from such technologies. If data are stored on blockchain, smaller companies and NGOs would be able to use data, computational power and run AI models. It can therefore democratize access to AI. Indeed, blockchain, on its hand, provides a decentralized control of data as well as computing resources while making them available. However, decentralization increases the network latency which needs to be speeding up if it needs to be used with AI (Skalex, 2020).

4.1.3.2 Your data, your right, your money

Today, data are in the hands of big companies which have created important AI models. This situation allows powerful companies to become even more powerful and smaller companies become even more limited (Eyal, 2018). Therefore, if we want train models, it is necessary to join these big companies, to trust them, their decision-making based on centralized sources of data where authenticity and provenance of data may not be accurate and results in risky and biased AI decisions (Dinh & Thai, 2018; Qi & Xiao, 2018).

Keep Data private, Monetization & Personal Care

Blockchain provides transparency and privacy over data. With the integration of AI and blockchain, users may be more eager to share their information as blockchain is secure and transparent (Eyal, 2018). It can therefore allow participants to control their data and to authorize the use over them by using authentication through the public or private key (Niforos, 2019). It is a way to ensure that data is shared if the user wants to and to ensure that our own data is not compromised as we can see who accessed the data, when and how (Dinh & Thai, 2018). Even if Google rewards you to get your data, the company would never own them and you can revoke the accessibility whenever you want (Skalex, 2020).

Finally, as the future of the medical sector relies on customized and predictive medical care, this may enhance personal care if the patient is in possession of his data and manages them (Nassar et al., 2020).

Data monetization and increase quantity

The data can therefore be immediately bought from the user and used for AI algorithms and this, in a fairer way. Consequently, the number of data could increase drastically, the little AI system shop will marry these data with their inventory to provide reliable recommendations and rewards to the consumer (Eyal, 2018). In consequence, an open-source system where data are shared and owners are rewarded by using tokens will emerge (Eyerys, 2020; Krittanawong et al., 2020).

Therefore, a power shift between those who created algorithms based on big data sets and those who can create powerful algorithms may happen (Everyys, 2020). Indeed, decentralized data marketplace will open up the creation of AI systems by smaller companies as normally access to data is expensive and kept private (Banafa, 2018).

Reduce biases

Anyone who has access to those anonymous data on a public ledger may gather a lot of data to train AI. As these data are protected, anonymous and from the global population, AI may be trained on less biased information and on global data. Therefore, it can provide a more representative sample of the population to the AI system (Skalex, 2020).

4.1.3.3 Secure data sharing, integrity

ML is data-hungry and needs full access to data, which is a problem for current AI development into the healthcare sector (Bresnick, 2018). As we have seen, the problem is the accessibility to high quality data and not the accessibility to AI system as it is now affordable (Eyal, 2018). If limited data are used, AI will provide limited models and with a higher error rate. Predicting a clinical event with a high percentage of potential errors is not permissible. That is where, the combination of these two intervenes (Bresnick, 2018).

Therefore, an idea would be to produce metadata about available data sets which are present in several organizations in order to gather as much data as possible. The blockchain would therefore point out to the place where the data are stored and will avoid moving the entire data set each time someone wants to do a transaction. With blockchain, the creation of persistent, unalterable, cost-effective, permanent records of documents, data and transactions is possible (Bresnick, 2018). Indeed, the current AI system, which is centralized and where data are collected from the user and owned by a server, is not completely efficient. Data duplication, transfer and protection can be enhanced with blockchain providing qualifying data and giving access to personal data to the end user by identification and keys (Niforos, 2019). For Banafa (2019), blockchain provides secured databases where different parties can look into, by « *combining blockchain with AI, we have a backup system for the sensitive and highly valuable personal data of individuals* ».

Indeed, blockchain provides highly secure, sensitive and crucial personal information which are signed and secured by the fact of possessing a private key and without intermediaries (Dinh & Thai, 2018). Indeed, Sharma (2019) affirms that we do not have any guarantee that data fed in AI machines are trustworthy. Blockchain gives that satisfaction and transparency as data are secured in the decentralized ledger and cannot be changed or altered. We can see where the data come from, where they have been transformed and the used code for the transformation for example (Alisson, 2019).

In addition, personalized medicine and health recommendations may be based on historical personal - geography, stress, atmospheric conditions, etc - and safe data (Campbell, 2018). If a user cannot see from where a decision comes from, it may be difficult for them to trust the result and the actions taken by AI – See the next section. According to Banafa (2019): « *Data on a blockchain, which can be accessed by an AI (...) could give us the enormous advantages of personalized recommendations while safely storing our sensitive data* ». In a nutshell, a data management based on blockchain could increase transparency, traceability and allow the use of quality data (Niforos, 2019).

4.1.3.4 Explainable AI and Trust improvement

As we have said in the AI part, it may be complicated to understand what happened in the *black box*. The made decisions are not easily explainable to a human and are, in

consequence hardly trusted. It will become even harder for specialists to explain the decisions taken by the machine as the AI algorithm will process an increasing number of variables and data (Banafa, 2019). In health sector, explainability is even more critical as life is put at risk and wrong decisions may be deadly. Therefore, an immutable trail for data and AI-based system behaviour is paramount.

The AI system will produce more authentic and reliable results as they will be trained on trustworthy data which is a critical challenge in data science (Marr, 2018; Niforos, 2019). With the trust deficit in AI application, a blockchain-enabled system can help to build trust. It helps to operate decentralized learning and to provide accurate outcomes thanks to many autonomous actors (McMahan et al., 2016; Wang et al., 2018). If the decision made by the robot is registered on blockchain, end users may be more eager to trust decisions as they could trace the process all the way back and understand where a decision comes from (Banafa, 2019).

Indeed, blockchain can help as an audit tool as it can monitor every step that have taken place and check the provenance of the data that go into the AI model as everything is registered on blockchain and with confidence that they have not been tampered. Therefore, it may be easier to determine who is at fault if something happens, the human or the machine (Dinh & Thai, 2018). Salah et al. (2018) affirm: « *Recording the decision-making process of an IA system on blockchain would increase transparency and it would gain public trust to understand the robotic decisions* ». It is on the contrary, not what the Skalex company, a cryptocurrency exchange software (2020) thinks. According to them, the black box problem of AI is something that cannot be solved with blockchain as some algorithms are complete blackbox which even developers do not understand.

It can also help with the bias aspect as if something weird or unusual happens, the blockchain technology helps discovering the source of this bias. Indeed, models always change and adapt over time. Using blockchain as an immutable tool will help to monitor these changes, to always be up to date, to track the evolution of the system and to adjust when needed (Bresnick, 2018).

AI issues and blockchain convergence is presented in *Table 3*. A more detailed table is available in the *Appendix P*.

AI issues → Blockchain benefits ↓	Privacy & Cybersecurity	Governance & Legal	Discrimination & Biases	Trust	Transparency & Explainability	Data accessibility	Data integrity, provenance & traceability
Immutability	X		X	X	X		X
Auditability	X	X	X	X	X		X
Privacy	X	X				X	
Anonymity	X					X	
Transparency & Traceability			X	X	X	X	X
Security				X		X	X

Table 3: AI issues with blockchain benefits – Solutions (From the author, 2020)

4.1.3.5 Geographical differences

As we talked about discrimination done by AI in the previous part, blockchain has the capacity to trace independent blocks and to provide granular data after segmentation. Therefore, variation in the result due to geographical differences could be traced with the use of blockchain. It is important for precision health, variation in drug metabolism between geographical regions or genetic groups. The incentive proposed before may help in the use and share of rare data (Krittawong et al., 2020).

For example, a convolutional neural network was recently trained and provided accurate diagnoses for arrhythmia. However, some categories such as developing countries are underrepresented and provide some biases or impracticable diagnoses due to a lack of data sets. Therefore, errors can occur, or results may differ. A blockchain enabled marketplace can, therefore, improve the integration of data worldwide, from other healthcare platforms and improve the quality of diagnoses (Krittawong et al., 2020).

4.1.4 Challenges to integrate AI and blockchain

4.1.4.1 Security & Scalability

Blockchain must be secure as an error in the health sector may be deadly. Using sensitive data is dangerous and may be monitored. Moreover, the 51% attack is a threat for data such as medical ones (Leloup, 2017). Therefore, as it has been seen in the blockchain part, security may to be rethought. In addition, today, blockchain scalability is an issue and is not able to support the big amount of the generated data needed to AI (Niforos, 2019).

4.1.4.2 Technology needed

As the blockchain technology is not well known and not easy to understand, it goes without saying that multi-disciplinary collaboration is needed to create such a system. Computer scientists, engineers, data scientists, statisticians and other professionals have to collaborate to treat these data and improve data management.

The energy-efficient processing needs also to be optimized as big data and the computing demand for data increase significantly and does not match with the current capacity. But the question is, how does the healthcare and medical service gather the data? The smart devices are integrated with the healthcare and medical services which consists of hardware manufacturers which manufacture and collect data through the creation of smart devices – wellness devices, sensors, etc (Seong-Kyu & Jun-Ho, 2020).

Moreover, even though this technology is really promising and kind of a dream-come-true mechanism, the implementation and acceptance remain difficult. The data integrity may be strict, and records need to be accurate and tamper proofed as AI works with large data sets which are critical for a patient's health.

4.1.5 Types of Blockchain used with Artificial Intelligence

According to Krittanawong et al. (2020), there are three types of blockchain used for AI. The first one would be the use of blockchain for data storing and the development of AI to predict some health issues and events. Secondly, the decentralization of data and AI algorithm – such as the incentive for health failure explain below. And finally, for AI-linked network of sensors to predict diseases such as cardiovascular disease.

4.1.6 Some Applications

Medical record and Cardiovascular medicine are presented here, Healthcare assistant and Biomedical research examples are available in the *Appendix Q, R*.

4.1.6.1 Medical record

If a patient wears smart sensors to monitor his medications intake, it will be easier to monitor him. It will also be easier, with AI system to detect any problems such as blood pressure or sugar level. All those details, may, thanks to blockchain be registered on medical records which are shared to every professional and kept up to date. Therefore,

an IoT application would detect data related to the patient's health and activities, AI would react on it and blockchain will help to verify and protect all that information. Moreover, AI could help with spotting anomalies, identifying threats and everything could be registered on blockchain (Bresnick, 2018).

4.1.6.2 Cardiovascular medicine

AI and blockchain can coexist to classify complex information and to provide some accurate data to AI used. Indeed, AI can assess cardiac function from different types of medical systems such as imaging or function from the electrocardiogram. Therefore, AI has a real potential in personalized cardiovascular solutions by defining novel phenotype, other than the traditional diseases. The system allows the improvement from predictions and therapy. However, it has some limitation. AI is data-hungry and there is a lack of large, heterogeneous, granular and available data sets (Krittanawong et al., 2020). That is where blockchain can intervene as it can provide secure, traceable, immutable and scalable data.

5. Conclusion & Future

According to several authors, the convergence of those technologies will not happen in the short term. Several steps need to take place regarding technical limitations, politics, social conditions, digital transformation and education. In addition, blockchain is still a recent technology where all the ins and outs are not known and where the acceptance is not reached. Both technologies face challenges and need to be enhanced separately before seeing a real convergence (Niforos, 2019).

As Banafa (2019) said: « *Putting the two technologies together has the potential to use data in ways never before thought possible. Data is the key ingredient for the development and enhancement of AI algorithms, and blockchain secures this data, allows us to audit all intermediary steps AI takes to draw conclusions from the data and allows individuals to monetize their produced data. AI can be incredibly revolutionary (...) blockchain can greatly assist in this* ».

Empirical Research

6. Methodology

This part aims to explain how the data have been collected, analysed and who has participated to this research. In addition, it explains on which framework the analysis is based and the reason behind this choice.

6.1 General Methodology

As it has been said, blockchain is a nascent technology. AI, on his side emerged in the 1940s, 1950s as seen in the literature review and knowledge about it is continuously evolving. As a consequence, the emergence of these two technologies as helping each other is really embryonic. Therefore, to investigate around this subject, an exploratory research has been conducted. On this subject, the educational portal, Business Research Methodology (2011) defines an exploratory research as an exploration about a problem or a topic which has not been clarified and defined yet. That type of research does not aim at providing a final and concluding decision but help to increase the understanding of the subject (Saunders, Lewis & Thornhill, 2012).

6.2 Method for Data Collection

Even though AI has been discovered a long time ago, it is not the case for blockchain which remains new and relatively unknown. In consequence, as it was already difficult to find and gather information about this potential convergence, it was even more laborious to find professionals having knowledge about both technologies and even more, within a health background.

Therefore, in order to carry on this research and bring comprehension to this topic, semi-directive interviews were conducted to collect empirical data. This qualitative method seems to be the more adequate one for an exploratory research where the subject is recent, unknown and where answers are expected. Indeed, according to Johnson & Onwuegbuzie (2004): «The major characteristics of traditional qualitative research are induction, discovery, exploration, theory/hypothesis generation, the researcher as the primary instrument of data collection, and qualitative analysis» which is the main goal of this thesis. Indeed, the semi-directive interview contributes to the elaboration of

knowledge for a qualitative and interpretative approach (Lincoln, 1995). The semi-directive method has also been chosen as we have interviews based on themes where the order may change regarding the answers giving by the interviewees, which makes that the conversation remains open. Moreover, it also requires going through unmissable points for the interviewer and to explore global knowledge about the cited subject (Muchielli, 2009; Imbert, 2010).

Therefore, in a semi-directive method, the elaborated questions are based on the literature review previously done. The beginning of the interview guide is general and then narrow down to more specific questions where the themes are explained, proposed and the questions are open (Imbert, 2010). It allows to enrich the questionnaire throughout the discussion (Gavard-Perret et al., 2008). In addition, the interviewee and interviewer have both the time to speak and share information during the discussion (Imbert, 2010).

Consequently, an interview guide has been created and presented in the *Appendix S*. This one is based on the ethical guidelines presented by the European Commission in 2020 and tackles most of the discussed topics. As this is a framework principally applying to European countries and not to the rest of the world, the assumption that we can expand it to the entire world has been made. According to the European Commission, to reach AI goal such as wellbeing and innovation program, it is important that the technology focuses on human. Indeed, putting AI in the service of humanity must be done while taking risks and challenges into account. For this, the European Commission, with 52 experts focuses on the elaboration of ethics guidelines for the development of a trustworthy AI as well as recommendations in terms of policy and investments in AI (European Commission, 2020).

This questionnaire contains four parts. The first one, is related to Blockchain, the second to AI, the third part consists of the integration of these two technologies to finish with a fourth part about the potential acceptance of this technology complementarity. This last part uses the Technology Acceptance Model (TAM) detailed in the *Appendix T* and presented in the next figure.

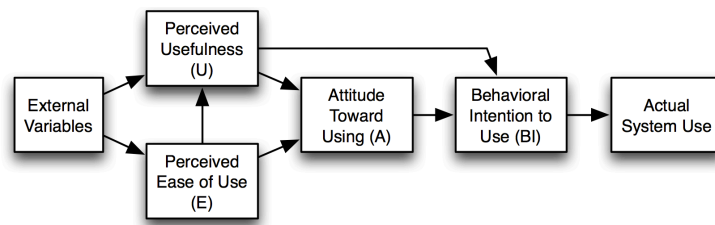


Figure 11: Technology Acceptance Model (TAM) (Sauro, 2019)

After the completion of this questionnaire, it has been transferred to a professor of the Université Catholique de Louvain who helped create a more adequate questionnaire.

6.3 Size and composition of the Sample

In order to carry on this research, the first step was to elaborate which type of profile was needed and the most appropriate to answer those questions. It is not necessary to say that professionals having knowledge about AI on one hand and Blockchain on the other hand was paramount. Indeed, as blockchain is seen in this work as a potential solution for AI, it was necessary to interview people having knowledge about how the technology works, its benefits, drawbacks and applications in the healthcare sector. The same logic applies to the Artificial Intelligence professionals which thanks to them, the AI issues are elaborated, explained and with who the potential solution coming from blockchain is explained. In addition, professionals having knowledge about both technologies were interviewed to have a systemic perspective.

To answer these questions, 13 profiles were selected. It has been done either via the social media LinkedIn, through some given conferences where the name of interesting professionals have been mentioned or through recommendations. Unfortunately, some professionals did not respond to the request even though multiple emails or messages have been sent. This is a limit which must be considered.

The 13 people interviewed, their name, the company they are working for and their position are presented in *Table 4* and are introduced in the *Appendix U*. Even though the number could have been higher, the lack of response from most of the contacted people makes that this is the maximum amount of responses we have been able to collect. However, as we can see in the next table, we have 2 doctors, 4 managers, 1 CEO, 3 directors, 1 consultant, 1 professor and 1 philosophe.

Participant	Function	Company	Duration
Ahmed Banafa	Professor	Stanford & San Jose State University	1'50 min
Philippe Coucke	Doctor	CHU Liège	45 min
Julian Fifield	Consultant	JRDF consulting	1,20 min
Bill Inman	CEO	Singularity Studio	35 min
Husen Kapasi	Manager	PwC	55 min
Robert Miller	Director	ConsenSys Health	1'00 min
Natalia Monteiro	Project Manager	Centiva Health	1'07 min
Jonathan Passerat	Director Cryptography	ConsenSys Health	1'08 min
Tim Richmond	Manager	SingularityNet	1'35 min
Hubert Ridolphi	Senior Manager/Pharmacist	ELCA informatics	58 min
Joan Van Loon	Managing Director	IBM	1'30 min
Daniel Yasri	Doctor Psychiatrist	CHU Montpellier	2'10 min
Emmanuel Goffi	Philosophe	Sapiens	60 min

Table 4: Participants

6.4 Data Analysis Method

After conducting several semi-directive interviews, these conversations were transcribed and are available in the *Appendix V*. After that, the interviews were sorted and reduced based on the thematic analysis method. This method is used to analyse qualitative data and presented in the *Appendix W* (Caulfield, 2019). To resume and treat data, the analyst has to use themes reflecting the information found in the interview transcript and resume it by identifying common themes (Paillé & Muchielly, 2012). The thematic analysis is seen as « *a good approach to research where you are trying to find out something about people's views, opinions, knowledge, experiences or values from a set of qualitative data* » (Caulfield, 2019). The goal is to explore and find more information about the research question. It will also help to make correlations, analyse discrepancies between themes and interviewees (Paillé & Muchielly, 2012). The used themes are based on the themes proposed by the European Commission on ethical guidelines for trustworthy AI (The European Commission, 2020). In addition, other themes have also been selected such as

definition, benefits, drawbacks of blockchain, AI and acceptance of the model. After the analysis, the obtained results are explained to then be confronted with the literature review.

7. Hypothesis

This part consists of presenting what are the main hypotheses of this work that we try to validate or invalidate. After that, they will be used in the analysis part by looking if according to the literature and the research, these hypotheses are true.

- H1: There is a lack of trust from users towards AI black box which can be tackled and resolved with blockchain technology.*
- H2: There is a lack of available data due to the monopoly from big companies and blockchain can help remove power to big companies and provide secure data to the smaller one.*
- H3: Healthcare is a late adopter and it is reflected with the adoption of AI and blockchain.*
- H4: The discrimination and bias occurring within the AI application can be outweighed with blockchain.*
- H5: Transparency and explainability of an AI system outcome can be overcome with blockchain.*
- H6: Blockchain can improve data quality and quantity fed into an AI system for training which will provide better and more reliable outcomes.*
- H7: Private Blockchain is a better choice for blockchain usage.*
- H8: Developing these new technologies will be harder in the Emerging countries as there is a lack of infrastructures.*
- H9: Blockchain can impact AI positively.*

8. Results

This part has a goal to present the results obtained during the semi-directive interviews.

8.1 Blockchain

8.1.1 How would you define blockchain?

Among the used words to describe blockchain, *decentralized*, *trust* and *immutable* have been mostly used by the interviewees. All of them have knowledge about the new

technology and agreed on its utility, apart from Jonathan Passerat which affirms that he was not a big fan of blockchain even though he sees the benefits of it.

For Tim Richmond, Manager at SingularityNet, and Philippe Coucke, doctor at CHU Liège, blockchain is a distributed ledger where transactions can take place in a decentralized way and without the intervention of a third party. This description has also been given by Daniel Yasri, Psychiatrist at the CHU Montpellier.

Hubert Ridolphi, senior manager at ELCA stressed on his side the fact that blockchain is a tool which allows trust improvement. Jonathan Passerat affirms the same statement by adding the fact that everyone participates in the network as it is decentralized and that, thanks to this chain of trust, trust towards a given process may increase.

Natalia Monteiro, project manager at Centiva Health declares that blockchain is a platform which allows to take actions that were normally unsecured in a more secure way. She also compares blockchain with the Internet affirming that blockchain is the Internet 4.0 but that for now, it is early, and everyone is trying to understand how it works.

Julian Fifield, Husen Kapasi and Ahmed Banafa used the word *cryptography* in the sense that the data are encrypted, and that people can use them if they have access to a certain private key. In addition, for some of them, consensus is an important concept as everyone agrees on the transaction and has a copy of the available information.

8.1.2 What are the characteristics of blockchain?

Besides the definition, the participants talked about the benefits as well as the issues that blockchain encounters today. As shown in *Table 5*, the opinions are relatively mixed while a lot of similarities pop up.

<i>Blockchain Characteristics</i>	<i>Banafa</i>	<i>Coucke</i>	<i>Inman</i>	<i>Kapasi</i>	<i>Miller</i>	<i>Monteiro</i>	<i>Passerat</i>	<i>Richmon</i>	<i>Ridolphi</i>	<i>Van Loon</i>	<i>Yasri</i>
<i>Decentralized</i>	X	X		X	X	X	X	X		X	X
<i>Security</i>	M	X				X				X	M
<i>Cryptography</i>	X			X				X		X	
<i>Transparent</i>	X		X			X		X		X	X
<i>Traceability</i>	X		X			X		X		X	X

Power	N							N			
TamperProof									X	X	
Immutable	X		X	X			X	X		X	
Trust	X	X	X	X	X	X	X	X	X	X	
Timestamp					X						X
Consensus	X				X		X				
Interoperability	N					N					M
Regulation	N					N					
Cost											N
Auditable									X	X	
Speed	N			X		X		N			N
Anonymous								X			
Scalability	N			M			N				M
Governance										X	

○ Mitigated
● Drawback

Table 5: Blockchain characteristics according to the respondents (from the author, 2020)

First, 10 out of the 12 interviewees gave trust and decentralization as a benefit:

- Joan Van Loon affirmed that «*blockchain helps to build trust*».
- Ahmed Banafa said: «*If the Internet is about connectivity (...) blockchain is about trust and that trust is actually among people*». He added, on top of this: «*You could be a node on the blockchain, and I have never heard about you*».
- For Natalia Monteiro, it is beneficial to use blockchain as there is a mistrust in the system from patients because they do not trust pharmaceutical companies which only have an interest in selling more drugs. With blockchain and transparency of the system, the trust may increase.

Regarding decentralization, the two doctors, Daniel Yasri and Philippe Coucke explained to which importance it is to decentralize the health information. They affirm that:

- Today, all the health sensitive data is centralized in a unique server and if a hacker hacks the system, he accesses all the patients' data.
- It is easy to hack a hospital.
- If the system shuts down, all the other computers in the network would still have the information as it is decentralized and those will not be lost with blockchain.
- They are keen that the data are encoded on blockchain to reduce the risk of losing the patients' data and to increase the interoperability between doctors and institutions.

However, interoperability may be a drawback for a few of them:

- Daniel Yasri explained that if tomorrow Belgium creates its own blockchain and Germany its own as well, they will not be able to intercommunicate. He affirms that interoperability may increase accessibility of patient medical records between professionals as he explained that if he goes to a doctor and then to another one, they will not have the same medical record. And if it is a doctor he never went to, he will not have any records at all.
- For Ahmed Banafa and Natalia Monteiro, this problem is due to a lack of standards. Natalia Monteiro, who is a member of the Ethics Committee (IEEE) creating standards for blockchain explained that there is a blockchain committee discussing the standards and what is ethically acceptable from blockchain.
- For Ahmed Banafa, the reason behind this is that blockchain is hundreds of billions of dollars' worth industry where nobody wants to share, and everybody wants to have control over the whole market. He added: « *You can go to Amazon and get your own blockchain, you can go to IBM and have your own blockchain, you can go to Microsoft, but you cannot mix them* ».

In addition, by the fact a transaction cannot be changed, blockchain is immutable and this point has been tackled by 7 out of 12 interviewees:

- As Daniel Yasri explains, the hash function present in the block header of a block allows to see the transaction integrity. If something from block 6 is changed for example, its hash will change because the hash of block 6 is the sum of all the transactions available in the block. If one transaction is changed, the hash of the block 6 changes and the hash of the block 7 as well as the following block depends on the previous ones. Therefore, the record is immutable and safe.
- Ahmed Banafa added that due to the blockchain structure, the information is encrypted, added to the next block and cannot be changed. However, he pointed out a way of changing the information. He declared: « *The only way to change whatever inside the blockchain is to have something called soft fork or hard fork. So soft work is a simple thing, like an upgrade. You change the size of the block and hard work is something wrong. If the information is wrong and you want to change it, you just start again, you stop this process, you start again from a different one* ».

However, thanks to that system, security may increase. 4 participants elaborated on this:

- Fifield explained that no one has ever hacked the blockchain so far. However, he pointed out that even if security issues may exist at the end, using a private blockchain helps to determine beforehand what are the rules, the participants, who can see and who can read the information. This may increase security compared to traditional systems which are riskier. In addition, he added that once you begin with blockchain, as there are a lot of nodes and because of decentralization, it is almost impossible to get rid of it.
- Joan Van Loon, Manager at IBM affirmed that companies which have to share information with each other can do it in a secure way, as nobody can change the information. He added that it was especially interesting in healthcare as: *« You have the labs, the hospitals, the patient, the pharmaceutical industry, (...) So there are a lot of players who all have different sets of information ».*

As we see on *Table 5*, two people have a mixed opinion about security:

- Banafa elaborated on the 51% attack which is still a problem that blockchain encounters. However, he stressed out the fact that it is difficult to do as a lot of computing power is needed. In addition, it does not worth it as it is time consuming and costly.

Traceability and transparency are two benefits which have been tackled six times:

- Ahmed Banafa explained that when a transaction occurs, you cannot see from who the information comes and to who it ends up. However, you can verify that the transaction is correct, which can help to trust the information.
- Daniel Yasri and Natalia Monteiro have taken the example of the medical trial to illustrate the transparency of the system. During a clinical trial, you cannot allow a doubt or a failure regarding the patient information. You need to be sure that you have given the right drug to the right patient. With traceability, the timestamping characteristic of blockchain and the data certification, blockchain increases the safety of the trial. Hubert Ridolphi also added that the auditability of the trial data is paramount and knowing the information has not been tampered is crucial.

Furthermore, for Kapasi and Monteiro, it increases speed while it is a drawback for Banafa, Richmond and Yasri. Kapasi affirmed that with blockchain, you can remove intermediaries and bottlenecks that prevent speed improvement. Joan Van Loon tackled the governance and affirmed that this one is maintained through: « *The fact that it is an open network (...) You have to be permitted to be part of the network to see some of the transactions, to see some of the data. Then it's basically self-regulating.* »

Finally, Daniel Yasri said that blockchain is costly and can help to increase the quality of medical care provided to patients as well as productivity and efficiency as better information is available. It can also help with quality of provided care as well as an increase in productivity and efficiency if you possess better information. Thanks to interoperability, patients may have better care as they will access their record everywhere. However, he also declared that blockchain is difficult to apply, to do and to code.

8.1.3 Which Type of blockchain for Healthcare?

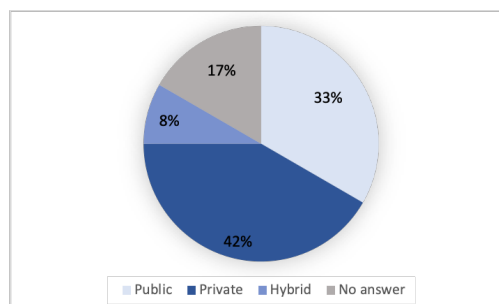


Figure 12: Which type of Blockchain in healthcare? (from the author, 2020)

As we can see on Figure 12, 42% of the respondents would rather use a private blockchain in the health sector instead of a public blockchain (32%). 8% would go for a hybrid one.

Ahmed Banafa who thinks a private blockchain is better for healthcare defined them as:

Private	Everybody knows everybody and you know who is behind a certain computer.
	Yasri*, who opts for a hybrid blockchain, added that the private blockchain requires the individual to be part of an institution for example. In addition, Monteiro and Banafa affirmed that an important number of nodes is needed.
Public	You do not know everybody and who is behind.
Hybrid	It as a mix of public and private blockchain where some information is on private blockchain while other is on public blockchain. People can access the blockchain without knowing the person's identity.

- *Yasri thinks a hybrid blockchain is better as he thinks that only certain person should have access to your medical record such as an oracle – a person who can validate the information such as doctors.
- Fifield opts for a private blockchain as: « *When you are dealing with multiple stakeholders in a value chain, they often do not trust each other (...) there is a kind of collaborative governance structure, which means people do not have to trust each other because they have agreed the rules of exchange between them. And the private chain means only those who have committed can join in. So all the data is not public. It is contained within the value chain. And everybody agreed the rules* ».
- The public blockchain is better according to Kapasi: «*It has to be a public blockchain so everybody can actually participate, first of all, and actually be trusted*».
- For Passerat, Miller and Ridolphi, public is better as consensus helps to increase trust in a public source of data. However, Ridolphi affirmed that it is expensive.

8.2 Artificial Intelligence

8.2.1 What is AI?

Different definitions for AI have been given by the interviewees. Ahmed Banafa and Daniel Yasri have specified that there is different type of AI: « *It is a small circle, which is deep learning, a bigger circle, which is machine learning and the bigger circle, which is AI*».

Different type of AI	Explanation	Example
Machine Learning	ML is about developing a program or a model which recognize certain features.	If a program is written to recognize people who are smiling, after that, the computer will be able to recognize people smiling thanks to features such as how far is the lips or the eyes.
Deep Learning	/	Why are they smiling? Is it a real or a fake smile? This is defined as DL.
Artificial Intelligence	Artificial Intelligence is a mix of Deep Learning and Machine Learning.	« <i>If you have more of deep learning than machine learning, then you are going to have more in-depth artificial intelligence that deals with emotions, deals with what's going on with a human being. If you have more machine learning programs, then you are dealing with patterns, insights like a business</i> »

Table 6: Different type of blockchain – Explanation (from the author, 2020)

- Joan Van Loon described it as a technology helping to find new features from data. He stressed the difference with traditional analytics where the goal is to find information from data and where AI creates new information and ideas from them.
- For Kapasi and Miller, AI makes sense of data which a human cannot read, has difficulties to understand and takes the meaning from these different data.
- For Passerat, it is the ability of a system to take an action on its own regarding a problem in a defined environment, such as the human does. Therefore, he will talk about Artificial General Intelligence instead of just AI.

8.2.2 What are the AI issues?

AI Issues	Banafa	Coucke	Fifield	Inman	Kapasi	Miller	Monteiro	Passerat	Richmond	Ridolphi	Van Loon	Yasri
Data Quality	X	X	X	X	X	X					X	X
Data quantity		X	X			X		X		X		
Data Privacy						X						
Update Data	X											
Professional	X											
Bias	X	X	X	X	X				X		X	
Unconscious												X
Comput. Power								X				
Trust		X									X	
Transparency				X	X						X	
Cult. adoption		X										
Liability		X										
Job replacement		X					X					X

Table 7: AI issues according to the respondents (from the author, 2020)

While asking for the AI issues the interviewees were thinking about, the quality of data and biases are the most important issues AI is currently facing. Indeed:

- 80% of the data scientist's time is devoted to data cleaning. The other 20% are about processing the data. It is also a challenge due to the continuous data that AI needs to keep running in order to avoid having a model based on old data.
- Dr Coucke affirmed that *garbage in, garbage out* is a real problem and that the quality of data in healthcare is critical. Indeed, there is no standardization regarding information and the way it is registered. Therefore, there is few quality data which is a real problem according to him. Everyone is protecting his or her data and is not ready to share them. He preconizes data philanthropy, for data to

be available for research while respecting data privacy. Fifield, Inman, Miller and Yasri confirmed this statement and specified that data pooling is paramount.

- Kapasi affirmed that all data are different, and an algorithm needs data that it can understand and process. Every company and hospital have their own data silos.
- Miller developed the idea of improving the relationship between users and algorithms' owners. It is important to show value to users' contribution when they provide data: « *I think if you reframe this relationship, you treated people as true stakeholders, then they would want to contribute more and maybe they would contribute to higher quality data* ». He affirmed that centralizing data such as the healthcare data which are sensitive is not a viable situation. A new system where data are private is needed, which can be obtained through a decentralization of the AI training.
- For Passerat, the current AI techniques used need to be rethought as they have two big constraints today: data quantity to obtain consistent results and the important calculation time needed. This statement is shared with Daniel Yasri. For Passerat, the only people capable of doing that kind of ML or DL are big companies.

Another issue tackled by Monteiro, Coucke and Yasri is the job replacement:

- Monteiro thinks that it will more enhance people's job than replacing them. However, for low level jobs, it will probably replace them.
- Coucke thinks that AI will not replace doctor's jobs but the doctor who does not use AI will disappear.
- For Daniel Yasri, automation may scare radiologists as AI can better read images than a human. However, he specified that a limit of AI is consciousness and the fact AI cannot make choices above the ones already programmed.

From the question of what are the issues AI is facing, bias is shared with 6 respondents:

- The problem comes from the human who programmed the AI, as he has his own belief while writing the program.
- For Van Loon, the data themselves can be biased as well as the human who is programming it.
-

Furthermore, Banafa raised the problem of skilled people. Indeed, there is a lack of data scientists who know programming, mathematics and psychology.

Finally, Philippe Coucke elaborated on the liability problem. Who is responsible if a problem occurs? It is even more difficult with an algorithm which evolves continuously because understanding the decision is even harder and legal aspects appear. In addition, the doctor talked about the difficulty of adoption which comes from a cultural problem according to him. Healthcare professionals are conservative and have the habits to rely on centralized data silos.

Joan Van Loon shared this idea of trust and added the transparency aspect. For him, you cannot let a machine tell a doctor what the diagnosis is without being transparent on how it came to the decision. It is important to increase trust: *« How does it use the information (...) and how does it come to a conclusion (...) the process in between is a black box (...) the trust and transparency is a very crucial thing. And this also relates directly to the data. Can the data be trusted? Is the data ethical? And again, that depends on the quality of the data that depends on the source of the data »*.

8.3 Blockchain and AI

8.3.1 AI and Blockchain general Idea

- *« Both technologies are really a match. They are the same level. They are not one is weak, the other strong » (Ahmed Banafa).*
- *« I admit that, in the ecosystem I advocate, and which is based on big data and AI, a system which allows a secure data exchange and where blockchain brings the solution needs to be put in place » (Philippe Coucke).*
- *« Blockchain is one of the few, if not the only potential mechanism for capturing truthful information. Conveying it across the supply chain or the value chain and then being able to perform interesting things with it, like artificial intelligence and machine learning on top of it (...) in health care, of course, the use cases for blockchain, AI and machine learning are immense » (Julian Fifield).*
- *« I think that blockchain can absolutely help AI in terms of Big Data. The triangular big data, blockchain, AI is really what makes that blockchain and AI can work together and are technologies of the future » (Daniel Yasri).*

- « It might help orchestrate the training of an AI, trigger certain actions at certain times, maybe decide parameters in which an AI can output a prediction. Maybe you need to pay or record an audit log of actions. And I think this ability to orchestrate things in a way that no single party controls are very useful generally and specifically within AI (...) The real potential (...) lies in its ability to create technology services that have a better relationship with users and are organized in a different way, where users have more choice of the algorithm that they're using and even have ownership over their algorithm, people are getting paid for their data, maybe there's more open marketplaces. And people's privacy is more respected » (Robert Miller).
- « AI, and blockchain is fantastic. It marries perfectly together, but it is the speed of the transaction and the volume of transaction being very slow and very small that is holding everything back (...) How we are using Blockchain with AI at Singularity is that our agent EcoSystem, which, you know, anybody in the world after proper approvals can post their AI agent into the singularityNet platform. And it is tokenized, so people actually get paid through the AGI token and by usage. So the more their AI agents that they post are used, the more they get paid with tokens » (Bill Inman)
- « I think they both have a purpose and a business case. And like we talked, there is a purpose and a business case for putting both together, but both could also perfectly exist, walk next to the other, serving their own purpose » (Joan Van Loon)

AI Issues solved with Blockchain	Banafa	Coucke	Fifield	Inman	Kapasi	Miller	Monteiro	Passerat	Richmond	Ridolphi	Van Loon	Yasri
Data quality, provenance & quantity	X	X	X	X	X	X	X	M	X	M	X	X
Transparency & Explainability	X	M	N	X	X	X	N	M	X	M	M	X
Trust	X	M	X	X	X	X		M	X	N	M	M
Discrimination & Biases	X		M	X	X	X	X	M	X	N	N	N
Governance & Legal								X				

● Mitigated
● Not a solution

Table 8: AI issues solved with blockchain - Respondents answers (from the author, 2020)

8.3.2 Data Management

As we can see on *Table 8*, data issues are issues which can be solved with blockchain according to 9 respondents while 3 of them are mitigated:

- For Banafa and Yasri, blockchain is an immutable record where data cannot be changed, where it is transparent, accessible and where trust in data increases. On the other side, AI helps to get insights from these data.
- Banafa added that using both technologies is useful as with the concept of *garbage in, garbage out* which is if bad data enter AI, the result will not be a result with quality. With blockchain, he affirms that once the information is stored on blockchain, nobody can change it which makes that the data can be trusted. The integrity of the data is secure and after cleaning them, AI can process them. However, Banafa specified that at this time, blockchain is not a real time technology but an almost real time. This means that you cannot extract the information right away from a car or a camera for example and process them immediately. He compared it to a situation where at the end of the day, all the hospital's data would be stored on blockchain, an AI can look at it and perform analysis. He also added that blockchain can save time because the data quantity can increase, and pure data would be accessible. Consequently, AI will be able to go faster through clean data. As blockchain and AI are software, you can use a smart contract to extract data, put the information in tables and it can be used by AI afterwards: « *There is an interface almost between the two. Because both of them are software so they can talk to each other very easily* ».
- Kapasi thinks also that it can help with data sharing if several companies use blockchain and not only two or three. Indeed, he stressed the fact that blockchain is a team sport and « *will make sure that each and every part basically gets in line and everybody has the same transparency and trust on that system that we agreed upon will be followed on that platform* ».
- For Fifield, blockchain can increase the accessibility to data and will facilitate the work as we do not have to go through a traditional system and database anymore. He added: « *Blockchain's primary ability and potentially if it is done right, is to capture accurate information and then effectively digitize it in a non-tamper proof way, which means if you got some accurate, truthful data, which cannot be tampered with, you can then start to run interesting artificial intelligence on top of it* ».

However, he specified that blockchain will not control if people will give access to their information. Especially in the healthcare sector where data is spread between silos and blockchain will not help to open up these silos. On the other hand, he affirmed that if the silos' owner decides to give access to data, blockchain can help to know who used the data, the utility and where they are going which gives a safe reason to open up your silos.

- Inman has the same opinion as Fifield. He says that there is a lot of data around the world and if a block-based platform can help to create secure and accessible data without preventing the anonymity or making the data public is a great use case of blockchain for AI.
- For Miller, more data sharing and usage will be possible by improving the trust from users by for example recording data permission with blockchain and after setting some boundaries, an immutable record that could be referred to as an audit log will help to determine when someone accessed the data, when and for which purpose.
- Richmond affirmed that blockchain and AI are like « *a marriage made in heaven* ». He integrated the use of IoT in the equation. He said that connecting everything via IoT and allowing every device to share its data while blockchain will help with the transaction between all these devices is great. AI, on its side, can see interconnections between a lot of information and needs to be able to interconnect these smart devices.

On the other hand, for Passerat and Ridolphi the use for data management is not sure.

- For Passerat, blockchain will not work alone because every information will be continuously duplicated. It is especially difficult with the GDPR rules and the right to be forgotten.
- Ridolphi thinks that blockchain can help with transparency, security and the source of data but not with data quality. He added that blockchain can help to gather historical data which is helpful in healthcare. He gave the example of a patient coming to hospital. If you need to know that 20 years ago, the patient had appendicitis and that his grandfather had cancer to treat him correctly, you would be able to do integrated care with blockchain.

8.3.3 Discrimination and Unfair Biases

As shown in Table 8, 6 professionals think that blockchain can help to reduce biases in AI while 3 think it will not help and 2 are mitigated. Among the ones who think it can help:

- Banafa, Inman and Kapasi affirm that as blockchain can save information without being subject to change or modification, the same information will always be available and not tampered.
- Miller also thinks that having a better sense of data being used can help to see if the sample used is representative of the population. Then, AI train on blockchain networks will not discriminate against someone.
- Richmond thinks that having no bias is impossible. However, having access to more data may reduce bias. As said, blockchain can help with data accessibility. Another solution to reduce bias would be to *« create something called a consensus decision making. So this is where you have different algorithms pointing towards the same outcome and then using blockchain to interconnect these algorithms, you can create a central algorithm which then is able to take the data and even it out. »*

Fifield and Passerat have a mixed opinion about the question:

- Fifield thinks that blockchain may help to reduce bias. However, there are other ways to reduce them and tackle the issue. As Yasri, he thinks that people are biased and not the machine. However, according to him, using blockchain can help to ask the question upfront. Indeed, having truthful data helps to not have dirty and biased data going through the system which help avoiding some of the potential biases.
- Passerat added that it could help but in an indirect way if it helps to access more data.

Yasri, Van Loon and Richmond think that blockchain cannot help to alleviate this issue:

- For Yasri, biases are due to human errors and more especially to a programming error. For him, the programmer did not code the divergence. Consequently, the AI is created for a certain type of person with a sample being non-representative of the population. He affirmed that it can also happen due to a lack of data and that blockchain cannot help in this matter. This statement is shared by the IBM manager, Joan Van Loon.

8.3.4 Trust Improvement

Table 8 shows that 6 of the professionals think that using blockchain for AI can increase the trust a doctor or a patient can have in AI decisions, while 4 are mitigated and Ridolphi is against. Among the positive attitudes towards it:

- For Banafa «*If Internet is about connectivity blockchain is about trust* ». Kapasi is on the same wavelength. Without blockchain, *garbage in, garbage out* and the core of the system is about data.
- Miller has also a positive feeling and explains that: « *training AI that will identify lung cancer or make some predictions (...) oftentimes these things are just like thrown out into the world and you have no insights into how they came to their conclusion. And there is no way to reproduce them, which is a central principle of the scientific method, is the reproducibility of findings (...) I think it is interesting to think about how blockchain can help solving that part of the problem of providing an audit log of the particular actions that were taken and the data sets that were referred to such a third party could go back, take the same actions, with the same sets of data, in the same code, and come to the same conclusion, the same algorithm, and to be able to reproduce what was made with a lot more integrity and trust* ».
- Inman, CEO of Singularity Studio thinks that: « *This really will help with the trust around the decision-making process, whether the AI was biased or not* ». Blockchain can store the result and the variables which help to come to a decision. Consequently, we can see if it has been biased towards a certain population or not for example.

Van Loon, Coucke, Passerat and Yasri have a mixed opinion:

- Van Loon said: « *blockchain can help with regard to trust in a way because if one part of the trust is knowing where the data comes from and knowing how the AI came to a certain conclusion, then it can also help, but it will not be able to help with the trust in the decision process as such* ». Indeed, for him, there is a step before the blockchain aspect which consists of opening the system created by the developers where you can claim if it is true or not. For him, you need to trust the machine.
- Yasri, on his side argued that it can help to reduce the error rate as the data cannot be tampered or changed. However, blockchain will not help to increase trust. This reason is since people do not trust a machine because they do prefer to be treated

by humans. Passerat is on the same page as Yasri's. It can help if we create an economy of data where we can access information, we could not have access to in the past. However, he said that making training in a decentralized way can increase trust between parties which do not trust each other. Using blockchain can help to register what happened and use it as an untampered ledger where everything that has been done is registered, logged and where everyone participates.

Finally, Ridolphi does not think that blockchain can bring trust in a system. It can help in a way that blockchain can ensure that the right person access the data but that is it.

8.3.5 Explainable AI

6 respondents think that blockchain can help to explain AI, 4 have a mixed opinion and 2 do not think it is possible:

- Banafa affirms that blockchain can document all the progress done by AI: « *Every time you get a result or you do something with the AI model, you document this one on the blockchain* ». Like that, they can trace back the result if needed.
- Yasri also thinks that you can trace back the decision but only if it is a ML which is using binary decisions and where the decision tree is registered on blockchain.
- Inman affirmed that blockchain « *should be used to store the results for every transaction, like the end result and how it got there, what are the data point (...) stored on the blockchain plus the final result so we know what variables and what data input created which result (...) Without that proof, you have metadata that could be manipulated* ».
- Kapasi added: « *Blockchain can trace each of the step (...) How you want to build the transparency in blockchain totally depends on how you develop the platform* ». In addition, he explained that you have the possibility to create a system on chain or off chain. When it is off chain, the blockchain is hosted on a cloud solution and you only store the hash of the data on blockchain.

For Coucke, Passerat, Ridolphi and Van Loon, they are not sure it can help:

- Passerat thinks that if it means putting AI on blockchain, it will not be possible, but it could be feasible if you ask precise tasks from the AI machine. This transaction would be registered on blockchain. If the system can be integrated with blockchain

and can register every action as an event, you can see what your action was, what is the result and what has been done with this information. However, he has a mixed opinion about the fact of opening the black box completely.

Regarding the impossibility to help:

- Fifield thinks it is ahead of time and does not see how it would be possible.
- For Monteiro, it is not possible and not needed as the model can go back by itself. You can always understand how it has been calculated. In addition, it is not really needed for her as a diagnostic done by an AI machine which is analysing a lot of images and data is better than a doctor's diagnosis.

8.3.6 Patient monetization

Finally, the opinion about data monetization is mixed:

- If you use a smart contract, you can program it by saying that if someone uses your data, he needs to transfer money to your account and informs you when your data are being used to allow the patient to have more control over his data (Banafa).
- Bill Inman added: « *Blockchain is a great use case for data to be leveraged by so that people can actually monetize their information and combine information because we need the fuel for artificial intelligence* ». It can help with personalization as well as with patients providing their data that companies cannot get.
- On the other hand, Passerat affirmed that it already exists, and a patient can participate in a clinical trial, can share his information and be paid for it.
- Miller thinks that it is still too early: « *People just do not have the incentive to share health records today. And different health records speak different languages. Blockchain won't solve that necessarily* ».
- Miller's idea is being shared by Kapasi who says: « *Rewarding the patient, the incentivizing is really undermined at the moment (...) because people do not understand (...) I think that is the key topic which will be coming in the next couple of years. The first one is consent, (...) you exactly know where your data is being used and who is using that (...) And the second thing is once you agree you have some kind of reward mechanism behind it, you get tokens to share the data* ». Ridolphi gave the example of a company who has launched an application where you can share your data for research in exchange of goodies.

8.3.7 Emerging Countries

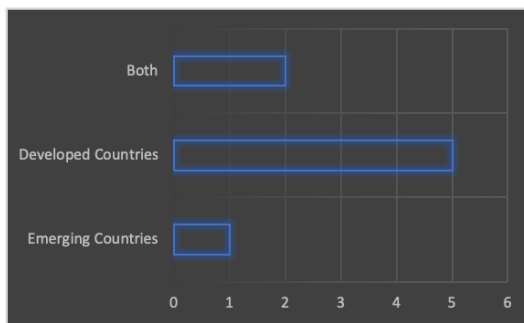


Figure 13: Where is it more difficult to implement those technologies? (from the author, 2020)

Most of the respondents think that it will be more difficult to develop these technologies in the developed countries. Joan Van Loon thinks that it will be difficult to integrate in both types of countries as it is not related to parts of the world but to available infrastructures and data. However, Fifield specifies that it will depend on the use case. Indeed, some may be adopted faster

in emerging countries and vice versa.

Opportunities	Difficulties
According to Banafa, Yasri, Coucke, Miller and Richmond, it can be easier to develop these technologies in the Emerging Countries because: ▪ It will make things digitized; ▪ There is less data privacy; ▪ They can monetize their work and it can be liberating; ▪ It is easier as everything has to be built, there is no existing structure to change; ▪ There is less resistance, opposition to change, regulation and legacy system;	Some difficulties may be faced in developing these technologies in Emerging Countries such as: ▪ Financial needs; ▪ Skilled people move to higher income countries; ▪ Political chaos; For Yasri, Coucke, it may be more difficult in developed countries because: ▪ There are legacy and political barriers; ▪ People do not like changes; ▪ There is high regulation.

Table 9: Opportunities and Difficulties while integrating Blockchain and AI in Emerging and Developed Countries (from the author, 2020)

8.3.8 Issues for integrating Blockchain for AI

Issues to integrate Blockchain with AI	
Banafa, Miller Kapasi and Van Loon think that:	▪ Standardisation and interoperability are needed. There is a need the IEEE brings standards. This is a big issue in healthcare as data are not shared; ▪ Compatibility between the different blockchain systems in order to use the same format of data.

For Banafa, Yasri and Miller there is a need of:	▪ Skilled people – Engineers, developers, people knowing both technologies.
Banafa, Yasri:	▪ Blockchain is expensive.
Yasri and Kapasi:	▪ Blockchain adoption is difficult. ▪ Awareness and education.
Yasri, Miller and Richmond:	▪ Speed, development and volume of a transaction.
Passerat and Kapasi:	▪ Technical difficulties, infrastructures.
Yasri adds:	▪ Complexity of each system, the complexity of using them together – coding, legal, data management, error management –, theoretical and scientifically complexity.
Inman has a different vision and thinks:	▪ It has not been proven that enterprises want to use decentralized systems and want to share their data through this kind of model, that they want to store their data in blockchain for AI and to remove intermediaries.
Kapasi:	▪ Understanding the complete endurance cycle of blockchain.
Miller:	▪ Sensitive data cannot be erased. ▪ Difficult to work with data off chain. ▪ Business model is uncertain and unsustainable.
Richmond:	▪ AI ontology: « What's holding it all back is the scalability of blockchain. What I personally believe needs to happen is the need to be a kind of mechanism that sits in front of the blockchain that is part of the blockchain, and that can lock up tokens or actual coins of one side and release on the other. And then it's not owned by anybody (...) But this introduces another resource or another obstacle for the overall system to get over and will slow everything down again (...) I think quantum cryptography can help with this by increasing the overall speed. And I also think that the structure of blockchain needs to change».

Table 10: Issues to integrate Blockchain with AI (from the author, 2020)

8.4 Technology Acceptance Model – TAM – for Blockchain and AI use case

8.4.1 Usefulness of the System

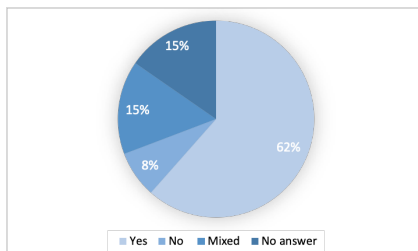


Figure 14: Is the System Useful? (from the author, 2020)

Eight interviewees affirmed that using blockchain with AI would be useful. For Coucke, Banafa and Inman it is essential and obvious while Miller and Van Loon affirmed that it will facilitate the developers job performance before improving the usefulness for patients and doctors. Miller affirms that it is already

useful but that in the future, it would be able to further improve the creation of algorithms as well as different technological services.

Kapasi, consultant at PwC affirmed that the number of demands double every year. For Ridolphi, we will not even see that blockchain is being used. For Passerat, it can happen but not with what is available on the market today. Yasri is also mitigated and specified that it can be useful only if the use case fits as a lot of people do not know today for what can blockchain be used.

8.4.2 Difficulty to Use

Seven respondents think that implementing and using blockchain for AI will be difficult. Two of them think it will be easy and two, Kapasi and Richmond, are mitigated. Indeed, Kapasi has gone through several steps to implement a use case in companies. The first year consisted to educate the client, the second year consisted of projects request and this year is about seeing how we can implement blockchain with different technologies. Richmond, on his side thinks that they are few AI developers and many of them work in large organizations. For Inman, Miller and Banafa, it will be easy to do but the evolution would be needed for it to be easier to use over time.

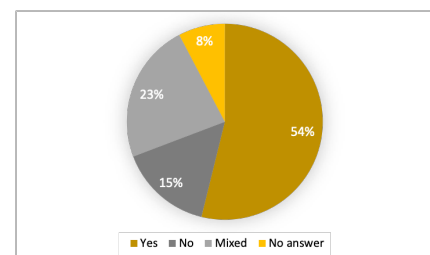


Figure 15: Is it difficult to use ? (from the author, 2020)

For Yasri, it is difficult as it cost money and knowledge. People need to accept to invest in people developing blockchain and having knowledge about healthcare. Hubert added that

it will take time and will need more clarity over the technology use, challenges and potential repercussions.

8.4.3 Attitude Toward Using the technology

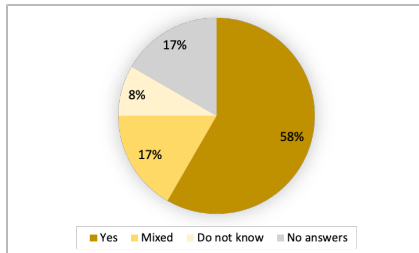


Figure 16: Would you go for it? (from the author, 2020)

7 of the respondents would go for a system like this one where Inman specifies that they are already leveraging it at SingularityNet. For Fifield and Passerat, there is a potential but not for now while Van Loon is mitigated, and Monteiro does not know.

8.4.4 Behavioural Intention to Use

Miller (7%) thinks it is understandable and clear while 21% of them are mitigated as it depends to who you are talking to. For Van Loon, people have difficulties to define the right use case but they do not need to understand the technology behind it. Yasri added that in the future, some people will

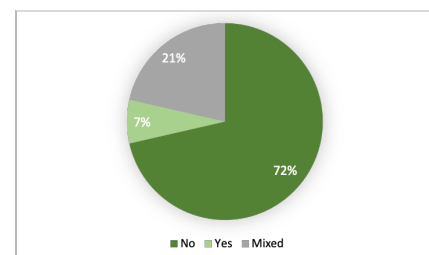


Figure 17: Is it Understandable and Clear? (from the author, 2020)

know both technologies and it will be easier. Coucke, on his side affirmed that the majority of healthcare professionals do not know what an AI is and even less what is Blockchain. Fifield and Inman think it is early and it needs to be clearer than it is today. However, for Banafa, AI is understandable, but the problem comes from blockchain. For him, the same level of understanding regarding blockchain and AI is first needed.

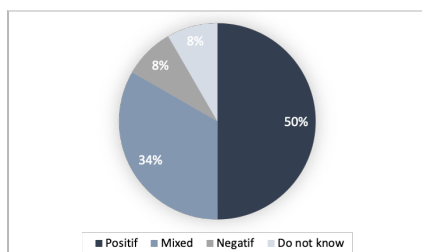


Figure 18: What is your feeling? (from the author, 2020)

Regarding the feeling of the respondents toward the implementation, half of them have a positive feeling while 34% are mitigated and Joan Van Loon thinks that blockchain may slow down AI (8%). Monteiro, on her side, does not know if AI needs blockchain. However, she thinks that blockchain could be a catalyst for AI regarding the access to data thanks to traceability and transparency

of blockchain.

For Fifield, Passerat, Richmond and Ridolphi who are mitigated, it is early. Passerat thinks that it will take time to polish both technologies and put them together while for

Richmond it is: « *Easy to feel both excited and scared about the use of AI (...) Ultimately AI technology belongs to humanity as a whole and Blockchain/decentralisation is how we get there* ». For Banafa, « *It's a perfect match (...) One of them is the muscle and one of them is the brain* ». Coucke thinks it is unmissable and a new system for healthcare is needed. Bill Inman has a positive feeling and thinks it is a necessary alternative to centralized AI.

8.4.5 Actual System Use

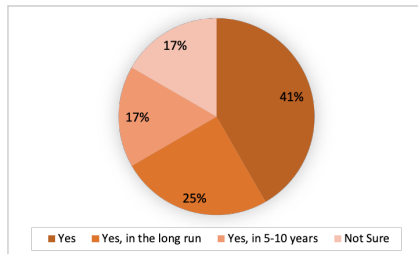


Figure 19: Is there a high probability AI and Blockchain are using together? (from the author, 2020)

With 83%, the probability of the two technologies to merge is high. 41% think that blockchain and AI are going to be used together, 25% think that it will merge in the long run and 17% think that it will merge within 5 to 10 years. For Fifield, it is two different technologies for now while Kapasi is already working on some use cases.

In addition, 75% of them think that blockchain improving literacy will be a prerequisite beforehand. For Coucke, it is essential to educate the new health students about technologies. Richmond also affirmed that education about all technologies is needed and not only blockchain. For Fifield, it is also paramount as a lot of people do not know what AI consists in and why they need it. For Inman, Banafa and Yasri, literacy is only necessary for professionals, decision makers, developers and people related with the subject but not the entire population.

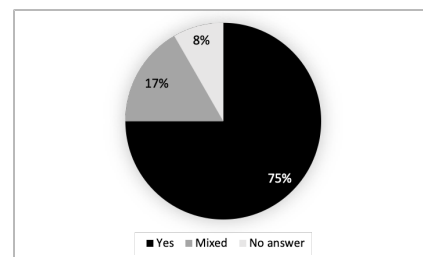


Figure 20: Does literacy need to be improved? (from the author, 2020)

9. Analysis

We have seen how blockchain can help Artificial Intelligence according to several professionals coming from different backgrounds and having different opinions about the question. In this part, the similarities and discrepancies between what is available in the literature and what we were able to observe during the interviews are analysed.

9.1 Blockchain the choice for healthcare

If we look at the study conducted by Deloitte, blockchain is a great technology if the problem which needs to be tackled faces: security, trust issues and the participation of

several parties. By looking at our research, these conditions have been confirmed. Monteiro affirmed that blockchain helps to take actions in a secure way, to install trust among people who do not trust each other and where different stakeholders – doctors, patients and others – interact together according to Joan Van Loon. However, using a new technology and changing the behaviour of people towards a new system is a challenge. Especially in the health sector which lags behind in terms of technological adoption. However, a surprising statement comes from Dr Coucke who declared that healthcare lags about 30 to 40 years compared to the 17 years announced by EY. This slow desire to change can be due to the resistance from the professionals who preferred to use known systems instead of new technologies which prevent the improvement of medical care.

Regarding the type of blockchain for healthcare, it seems that the private one remains the first choice as developed in the literature. This does not mean that public blockchain will not be used as it depends on the use case. Another important part of the respondents would choose the public one while the rest would opt for a hybrid type of blockchain. Zhen et al. (2018) affirmed that a public blockchain may be better such as Kapasi and others.

9.2 Blockchain, the technology of trust

Most of the interviewees have described blockchain as a *decentralized, immutable* and *trustworthy* technology. Indeed, decentralization is paramount and gives the ability to share the consensus and to have backup systems in case a system crashes as we have seen in the theoretical part. It is an important point which has been raised by the doctors, Yasri and Coucke who affirm that if the current centralized system crashes, all the patients' data are lost. Thanks to blockchain, copies exist everywhere.

Nevertheless, regarding the technological aspect, the scalability of blockchain, which is undeniably an issue exposed in the literature may be an issue which is currently being tackled or for which solutions already exist. Respondents have affirmed that scalability depends on the type of blockchain the developer wants to create and that he must think about how he can make the blockchain scalable to fit his use case – such as AI. It is not an issue anymore and some solutions exist or are being created to tackle this problem. It is an astonishing result as several authors have affirmed that scalability is a current problem and may prevent the development of blockchain to a larger scale. The manager of

SingularityNet, a company developing blockchain for AI thinks that scalability is what is holding all back. Therefore, the question must be deeper analysed to see if the problem can be solved.

Furthermore, blockchain is a secure technology offering immutability. As it is presented in part 3.3.2, the information cannot be changed due to the hash function which increases security. For a sector such as healthcare where data is sensitive, it is beneficial as a falsification can be detected and invalidated. The hash system has also been explained by Crosby et al. (2016) and confirmed by Yasri. However, a way of changing the information has been explained by Banafa and is not available in the literature. For him, the information is encrypted and cannot be changed besides if you face a soft or hard work system which corresponds to changing the size of the block or starting a new process again.

Additionally, immutability is one of the points which shows that blockchain is secure. Cryptographic proof and decentralized monitoring make the transaction safe as explained Leloup (2017) and as Van Loon affirmed. However, the 51% attack is elaborated in the 3.3.2 section and is presented by the respondents who explained that this is a threat. This one is particularly difficult to do as it is energy intensive and time consuming. Blockchain has never been hacked so far and is secure. However, it is not impossible that someone tries to hack the system with the increase of computational power.

Talking about immutability, it goes without saying that the Art. 17 of the GDPR, the right to be forgotten, is a major topic in today's discussion about blockchain. As several authors explained, the technology does not afford any changes due to the hash function. Even though it has also been confirmed by some interviewees, others think differently. There are stronger rules than the GDPR in the health sector as it is highly regulated. For Yasri, it is not impossible to do. You can add a transaction above the previous one. As the last block will contain all the information someone wants to share, with time, the one containing this information will be too far. However, it seems that the information never disappears with this solution. In Monteiro's company, they use smart contracts which can be revoked, and the patient can share its information only for a certain period and then stop.

Finally, the lack of standards has been pointed out by several authors such as Mougayar (2016) as well as respondents during the interviews. Standardization could help with interoperability of the system, share implementation and facilitate the transfer of medical data. However, Monteiro who is a member of the IEEE Committee affirmed that they were currently working on standards over the blockchain use in the pharmaceutical industry. For Banafa, it is a run towards who has the bigger control over the blockchain as you can go to Amazon, IBM and others to get your blockchain, but you will never be able to make them work together. This is a problem which needs to be solved as being able to share information between different blockchains may help to access several data.

9.3 Artificial Intelligence, the artificial human brain

AI in healthcare faces some challenges such as bias, transparency, data quantity as well as the acceptance and trust in new technologies by end users. Data quality, quantity and bias seem to be the most important issues AI is facing according to the respondents (*Table 7*). In addition, a lack of trust in the AI *black box* prevents the adoption of this technology. According to the PwC (2020) research and confirmed by Coucke as well as Van Loon, 38% of the respondents do not trust a machine, even if this one performs in a better way.

During the interviews, we tried to see if using blockchain to reduce these issues were possible as found in the first part. It results that data management issues can be solved by using blockchain as we can see in *Table 8*. For explainability of an AI decision, trust and biases, it is not as sure as for the data. However, even though six respondents are in favour of the possible use, the one who are mitigated are not completely opposed as under certain conditions, blockchain can help. Indeed, trust is an important aspect which is holding the adoption of AI technology back. However, only 6 of the respondents affirm that blockchain can help to increase trust while the opposite was explained in the 4.1.3.1 part. Even if half of the respondents claimed the same idea as these authors, Miller added an element which consists of increasing trust as blockchain could provide an audit log of the particular actions that have been taken and allows the reproducibility of the algorithm with more integrity and trust. However, Ridolphi does not think that blockchain can help with trust. For the others, if blockchain could help, it will only be in an indirect way.

In addition, as we have seen in the literature, blockchain could help to explain decisions taken by AI and help with the AI *black box* problem. This aspect could increase trust according to Marr (2018) as decisions and used variables could be traced back and the evidence that data have not been tampered can be provided. Half of the respondents agree with this while others think it can help to see the actions, the results and which information has been used but, opening the *black box* is not possible. For a few of them, it is not possible and useful as a diagnosis made by a machine is better than a human. However, if it becomes possible, it would be interesting.

Regarding data, it seems that blockchain could be a good catalyst for AI to access more and reliable data. Consequently, more reliable results may come out of the AI machine according to Niforos (2019) and other authors. It has been exposed that blockchain helps to see where the data come from and if they have been changed. Kapasi, who agrees with that statement, has specified that several companies need to use blockchain in order to have an impact as having only one or two companies may be useless.

Furthermore, we have seen that bias is a major problem and that data tampering, manipulation and provenance may be some of the reasons why decisions are biased according to some authors. The EC (2020) affirmed that the system cannot produce results which are based on missing or biased data to avoid bias in output. Nevertheless, some biases cannot be overcome by simply increasing the data quality and quantity as the problem comes from the human who is programming it as he is naturally biased. Therefore, with blockchain, the AI machine can be trained on trustworthy data and can provide reliable outputs. This is confirmed by six of the respondents but invalidated by Yasri and Van Loon who think that the lack of data and the human factor are the reasons why models are biased. However, for Fifield, even if bias is due to humans, having trustworthy data upfront can help to reduce it as well. Richmond provides a solution not tackled in the literature which is creating a consensus decision where you interconnect thanks to blockchain, some algorithms and create a central one.

Moreover, we have seen that big companies own a lot of data which creates data silos, prevents personal health improvement and R&D. AI power is also monopolized by big companies due to a lack of data, talent and computing power according to Dinh & Thai

(2018). However, at SingularityNet, some solutions are currently being provided. They are creating an AI marketplace based on blockchain where people can share their AI and receive tokens in return. However, Banafa affirmed that blockchain is not liked by big companies as when data is decentralized, copies exist everywhere and there is no way for them to make money out of it. By using a smart contract, the patient can give permission or not to some personal information and choose if he wants to share his data. It has also been said that NGOs and smaller companies would have access to more data in order to run AI. Daniel Yasri counter argued this statement saying that the big companies such as the GAFA companies have a lot of difficulties collecting health data and that data monetization and decentralization via blockchain will be a catalyst for data collection by big companies. In a society where the patient is reluctant about sharing his data, it will become common in a system where the patient can be rewarded. They will be more eager to share their data which can be beneficial for big companies.

9.4 Development of new technologies in Emerging Countries

It appears that people in developed countries trust less AI machines and that adoption and implementation is harder than in the emerging countries. The study conducted by PwC (2017) has been confirmed by the respondents as according to most of them, there are no legacy systems, no existing infrastructures, less resistance as well as less opposition from the population preventing the implementation of these technologies. If nothing exists, having something is always better. However, the lack of infrastructure can also be a drawback for these developments.

9.5 Challenges

Developing and integrating new technologies come always with challenges. However, these challenges seem to be less than the one explained by the interviewees. In the literature, blockchain security, implementation, complexity, adoption and scalability have been the main issues while interoperability between the system, awareness and education popped up as being important issues according to the respondents.

After analysing the potential challenges the integration may face, it seems that most of them are coming from blockchain. It is not surprising as blockchain is not well known, complex and not easy to understand. This has been pointed out in the literature and

confirmed by the interviewees. This is the reason why it is specified that collaboration between specialists is needed as well as an increase in awareness and literacy.

9.6 Future adoption

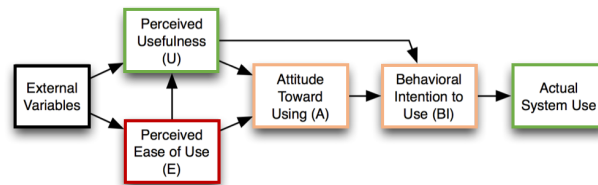


Figure 21: TAM Model for the Blockchain and AI use case (from the author, 2020)

As we can see on Figure 21, the general feeling about the usefulness of integrating blockchain with AI is positive and seems useful. As experienced by Kapasi, the demand in the consulting world for implementing these new systems have doubled every year during the last three years. Indeed, the difficulty is major as there is a lack of developers and that healthcare is not an innovative sector. However, it seems that the attitude toward using it is not negative and a good evidence is that they are already leveraging it in some companies such as SingularityNet. The mitigate aspect comes from the fact that it may be developed and common only in the long run. However, as it is expected to become easier over time, it seems that most of them have a positive feeling towards the use of blockchain for AI. Others think it is still early but not impossible, which makes that overall feeling positive. Some of them, especially the doctors are really excited about the idea of facilitating their way of working and increasing the quality of medical care.

- Positive
- Negative
- Mitigated

However, before coming to this stage, it must be more understandable and clearer. This makes that, in order to reach the system usage, the literacy and awareness of blockchain are paramount. Once it is done, the challenges would be overcome, and the users ready to adopt, blockchain for AI may appear.

9.7 Discussion: A philosophical perception

To finish up, it is paramount to bring an openness to the subject which has been presented by Emmanuel Goffi, AI Philosophe working at the Sapiens Institute.

First, Mr Goffi raised the importance of understanding the meaning of the words when talking about the topic. What does being intelligent mean? For some, intelligence is reflected by having a high intellectual quotient while others have a different definition for the same word. The same logic applies to humans. What does being a human mean? In tomorrow's society, it is possible that a human will be composed of several intelligent members and machines. But, would the half-human, half-robot person still be considered as a human? Even though the adoption to all those technologies may bring concern, fear and a lack of trust from the population, using these new materials will become common over time. Indeed, people will get used to it and new generations will probably be acculturated which will facilitate future implementations. For example, 10 years ago, drones were prohibited in the military service as pilots were afraid that this new technology would replace them. Today, the army is using several drones and this, for different usage.

Moreover, cultural differences must be considered. Indeed, the meaning, the definition as well as the usefulness of ethics is different in every culture. Explainability, data privacy or even transparency are mainly occidental based concerns. Asia, Africa or the Middle East do not have the same issues as Western countries. Indeed, it goes without saying that the GDPR shows the importance of data privacy in Europe but, in China data privacy is not a relevant question. The same applies for ethical questions when talking about Morocco where Islam is present and where we do not ask questions about acceptability or non-acceptability of a decisions made by the authority. Colour, gender or religious bias are not universal. Gender bias in Saudi Arabia is not important, same for the social status bias in India. Bias are not equally considered in every place of the world. As Mr Goffi said, these are non-real problems. However, standards are established and when working on these topics such as blockchain and AI, a lot of documents are done by the same kind of people, where the same kind of questions are answered and where the availability is limited to language such as French or English, besides for multilinguals people who can extend their researches.

Therefore, some established problems are not authentic problems such as explainability. In addition, AI will become even more complex and programmers will neither be able to explain a decision. And even if they are able, people who will understand the meaning will

be limited. Only professionals or informed people will have access to the information. Therefore, increasing trust is a work and progress which will be done over time.

Those issues are marked by culture and are dedicated to specific parts of the world. In China, human rights are not paramount. It does not mean they do not care about the human; it is just that they do not understand the concept. However, we found those principles in China as well. Where, according to Emmanuel, the only reason behind is that China wants to penetrate the European market with its products. If they do not do it, they will not be able to export them and to gain competitiveness.

To conclude, it is important to think about the semantic of the words and to see which meaning a word has, in which context, in which culture and for which person. It is also paramount to open the discussion of such a subject to other nations and to see what the real issues are over there and if we really can bring standards to these countries when these are established by a centric occidental vision. This is a western point of view and opening and expanding the ethical question and concerns to other countries may be something to consider.

Conclusion

10. General Conclusion

10.1 Conclusion

To conclude, this thesis focuses on the new technology of blockchain as a potential solution to some of the issues AI may face. Therefore, the research has been based on the exploratory question elaborated at the beginning: « *Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence* ». The objective was to analyse this new topic and to see what are the benefits that blockchain can bring to AI.

First, after looking at the healthcare sector, it appears that this is an industry which is relatively reluctant to change and where digitalization is not up to date. It also comes out that bias is still something present due to the known problem of *garbage in, garbage out*. Indeed, there is no current guarantee that the data used to feed into AI are trustworthy and not tampered. In addition, it appears that the liability issue is not a solved problem today and that legal aspect is still a question mark. Regarding traceability and explainability, blockchain turns up to be a potential solution to this as well as to the lack of trust in AI machines if information and decisions can be traced and if reproducibility is feasible. Indeed, blockchain revealed being « *a new, decentralized and global computational infrastructure that could transform many existing processes* » and is expected over a 10-year horizon to be subject to 3.1 trillion of dollars of investment.

Secondly, the methodological research used to tackle the question has been explained as well as the European Commission ethics guidelines and the TAM model. After establishing the interview sample and conducting these ones, the results have been explained using tables and pie charts which summarize the answers received by the professionals. It helped to highlight the feelings and ideas professionals have today about the topic which is mostly positive even though difficulties will be encountered.

Finally, the last part of this work helped to answer the previously elaborated question based on the hypotheses. It appears that blockchain can positively impact AI (*H1*) if the use case is well thought and adapted. However, it can take time as healthcare is a late adopter and not inclined to follow other industries on digitalization (*H2*). However, it

seems that the previous elaborated hypothesis (*H3*) concerning development in emerging countries have been refuted. Indeed, as there are no legacy systems and existing infrastructures, the implementation seems easier in these countries.

However, regarding data management (*H4*), blockchain is a great tool to use. Indeed, more reliable, secure and non-tampered data can be fed into an AI machine in order to bring better and more accurate results. As data cannot be changed due to the hash function and cryptography, we can ensure that the used data are reliable according to most of the respondents. It joins what has been declared by some authors. However, while not enough elaboration has been made over the data owned by big companies, a lot of mitigation appeared around this question. Even though it has appeared in the literature that blockchain could help to remove power from big companies in term of data ownership (*H5*), it appears that it is not really the case. For Yasri, it will even open access to more data if big companies could pay to access the patient's data. However, as said, opinion is mixed, and others think that it can cut the value chain and make information available easily.

It is also the case for the lack of trust in the AI machine (*H6*). According to the respondents, even though half of them have affirmed it could help with trust, it is not what the majority thinks. Trust can be brought to AI with blockchain but in an indirect way which could be tackled with another system than blockchain according to them. The same statement applies to bias (*H7*) and traceability & explainability (*H8*) as opinions about the question are mitigated. However, six respondents affirm that it can help as having biased or missing data can bias the output according to the EU commission (2020) and can be reduced with blockchain according to the respondents. However, others are mitigated and think that bias comes from the human programming the machine. We also deduced that the traceability potential of blockchain can help to a certain extent to explain decisions, to allow reproducibility, show the used variables and information. Even though only six respondents join what has been said in the literature, others are not completely opposed and will let it to the future to see if it is possible.

10.2 Future Development

First, some of the solutions proposed for AI issues are mitigated from the respondents as well as from the authors and can therefore not come to the full conclusion that it is going to help. However, it does not mean that there is no possibility that blockchain helps AI in the future. Indeed, some respondents affirmed they never heard about certain information so far as the subject is recent. Some issues which are not sure to have solutions today such as scalability need to be followed and tackled by scientists to try unblocking the situation in the near future and leave room for development and use.

In addition, the way blockchain can interact with AI does not stop at what is presented here. As we already talked about, AI can also help blockchain and it would be interesting to tackle other subjects such as joint decisions or decentralized computing power.

Finally, as Julian Fifiield said, if the same work would have been done in 10 years from now, the questions and answers would not have been the same. For now, the situation is still at its beginning and some companies are starting to try to implement some blockchain-AI solutions. The subject and the aftereffects must be closely followed and see in a few years what are the results of such new solutions.

10.3 Critical Perspective

It seems important to have a critical point of view regarding blockchain in order not to think that the technology is a miracle solution and that if AI is used, blockchain must be used. Thinking deeply about the use case, the situation and the potential needs is essential. If some characteristics are not fulfilled, other solutions which may be less expensive, less difficult and less restrictive would potentially better fit the problem. Furthermore, before using the technology, it seems important to call in an expert to see if it worth spending money in developing such a new solution. Especially at the beginning when it is not common and when people do not really understand the real goal of blockchain.

Finally, this work does not reflect all the possibilities that blockchain offers and even less all the benefits that blockchain could bring to AI. Indeed, this thesis has limits and does

not afford to tackle other aspects. Other researches and discoveries need to be done in order to see every opportunity of these technologies together.

10.4 Limitation

Even though consistency and rigor have been followed during the research, limitations to this exploration which may have altered the quality of the work have to be raised.

First, the subject is nascent and still at his embryonic stage which makes that available information is limited and may have biased some aspects of the work. In addition, as finding papers in favour of the topics was already difficult – and especially specific to the healthcare sector – it was not easy to find articles which countered what was affirmed in the existing articles to bring a contradictory opinion in the literature.

A second limit to consider is the number of interviewees. Even though it is a qualitative sample and that the maximum number of respondents have been reached, interviewing more people would have been interesting in order to gather more insights about this subject. It would also have been possible if more time was available.

Finally, biases may exist due to the comprehension of the nascent topic on the respondents' side even though they were professionals and aware of the subject. In addition, biases coming from the Occidental point of view need to be considered and may prevent an openness regarding the situation in the rest of the world as suggested by the Philosophe, Emmanuel Goffi.

References

- Alexander, A., & Ballou, K. (2018). *Work life balance, burnout, and the electronic health record*. Am J Med.
- Alexandre, L. (2017). *La guerre des intelligences*. Jean-Claude Lattès.
- Ali Siyal, A., Junejo, A., Zawish, M., Ahmed, K., Khalil, A., & Soursou, G. (2019). Application of blockchain technology in medicine and healthcare: challenges and future perspectives. *Cryptography*.
- Ali Syed, T., Alzahrani, A., Jan, S., Shoaib Siddiqui, M., Nadeem, A., & Alghamdi, T. (2019). A comparative Analysis of Blockchain Architecture and its Applications: Problems and Recommendations. *IEEE AAccess*, 7.
- Ali, T. (2018). Z notation formalization of blockchain healthcare document sharing based on crbac. *J. Inf. Commun. Technol. Robot. Appl*, 9, 16-29.
- Allen, R. (2020, November 13). *Digital Marketing Models: The Technology Acceptance Model*. Retrieved from Smart Insights: <https://www.smartinsights.com/manage-digital-transformation/digital-transformation-strategy/digital-marketing-models-technology-acceptance-model/>
- Allison, I. (2019, December 6). *Microsoft Is Using Blockchain to Help Firms Trust AI*. Retrieved from Coindesk: <https://www.coindesk.com/microsoft-is-using-blockchain-to-help-firms-trust-ai>
- Arnold, A. (2017, October 17). *Blockchain: A new aid to nuclear export controls?* Retrieved from Bulletin of the Atomic Scientists: <https://thebulletin.org/2017/10/blockchain-a-new-aid-to-nuclear-export-controls/>
- Baliga, A. (2017). Understanding blockchain consensus models. *Persistent*, 4, 1-14.
- Banafa, A. (2019, May 06). *Blockchain and AI: A Perfect Match?* Retrieved from OpenMind: <https://www.bbvaopenmind.com/en/technology/artificial-intelligence/blockchain-and-ai-a-perfect-match/>
- Becker, J., Breuker, D., Heide, T., Holler, J., Rauer, H. P., & Böhme, R. (2013). *Can we afford integrity by proof-of-work? Scenarios inspired by the bitcoin currency*. Berlin: Springer.
- Benet, J. (2014). IPFS-content addressed versioned P2P file system. *Computer science*.
- Benjamens, S., Dhunnoo, P., & Meskó, B. (2020). The state of artificial intelligence-based FDA-approved medical devices and algorithms: an online database. *Nature Partner Journals*.

- Bragagnolo, S., Rocha, H., Denker, M., & Ducasse, S. (2017). *Smartinspect: Smart contract inspection technical report*. Inria Lille.
- Bresnick, J. (2018). *How AI, blockchain Combine to fuel healthcare big data analytics*. Retrieved from Health IT analytics: <https://healthitanalytics.com/features/how-ai-blockchain-combine-to-fuel-healthcare-big-data-analytics>
- Brodersen, C., Kalis, C., Leong, C., Mitchell, E., Pupo, E., & Truscott, A. (2016). *Blockchain: Securing a New Health Interoperability Experience*. Accenture.
- Business Research Methodology. (2011). *Exploratory Research*. Retrieved from Business Research Methodology: <https://research-methodology.net/research-methodology/research-design/exploratory-research/>
- Cachin, C., Sorniotti, M., & Weigold, T. (2016). *Blockchain cryptography and consensus*.
- Campbell, D. (2018). *Combining AI and Blockchain to Push Frontiers in Healthcare*. Retrieved from macadamian: <https://www.macadamian.com/learn/combining-ai-and-blockchain-in-healthcare/>
- Castellino, A. (2018). CancerSEEK: Blood Test that Detects Eight Common Cancers. *Medscape*.
- Caulfield, J. (2020, August 14). *How to do thematic analysis*. Retrieved from Scribbr: <https://www.scribbr.com/methodology/thematic-analysis/>
- Chen, I., Szolovits, P., & Ghassemi, M. (2019). Can AI Help Reduce Disparities in General Medical and Mental Health Care? *AMA Journal of Ethics*.
- Cleverence, K., Mussa, A., & Sam, A. (2018). A review on healthcare information systems and consensus protocols in blockchain technology. *Computer Science*.
- Colyer, A. (2016, July 4). *Natural language understanding (almost) from scratch*. Retrieved from the morning paper: <https://blog.acolyer.org/2016/07/04/natural-language-understanding-almost-from-scratch/>
- Corti. (2020). *Corti*. Retrieved from <https://www.corti.ai/>
- Coucke, P. (2019). *La médecine du futur: Ces technologies qui nous sauvent déjà*. Bruxelles: Mardaga.
- Crosby, M., Nachiappan, Pattanayak, P., Verma, S., & Kalyanaraman, V. (2016). BlockChain Technology: Beyond Bitcoin. *Applied Innovation Review*.
- Davenport, T., & Kalakota, R. (2019). The potential for artificial intelligence in healthcare. *Future Healthcare Journal*.

- Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of information Technology. *Management Information Systems Research Center, University of Minnesota*.
- Dean, J., & Ilvento, C. (2006). *Improved cancer detection using computer-aided detection with diagnostic and screening mammography: prospective study of 104 cancers*. *AJR Am J Roentgenol*.
- Denchak, M. (2018). *Fossil Fuels: The Dirty Facts*. Retrieved from NRDC: <https://www.nrdc.org/stories/fossil-fuels-dirty-facts>
- Dinh, T., & Thai, M. (2018). AI and Blockchain: A Disruptive Integration. *Computer*, 48-53.
- Ekblaw, A., Azaria, A., Halamka, J., & Lippman, A. (2016). A Case Study for Blockchain in Healthcare: “MedRec” prototype for electronic health records and medical research data. *IEEE*.
- Engelhardt, M. (2017). Hitching Healthcare to the Chain: An Introduction to Blockchain Technology in the Healthcare Sector. *Technology Innovation Management Review*.
- Ernst&Young. (2019). *What connections will move health from reimagining the reality*.
- Estey, E. (2009). Robotic prostatectomy: The new standard of care or a marketing success? *Canadian Urological Association Journal*.
- European Parliament. (2016). Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).
- Eyal, E. (2018). Blockchain will make AI smarter by feeding it better data. *venture Beat*.
- Eyerys. (2020). *How Blockchain Can Make AI Smarter By Feeding It Better And Unbiased Data*. Retrieved from Eyerys: <https://www.eyerys.com/articles/how-blockchain-can-make-ai-smarter-feeding-it-better-and-unbiased-data>
- Gartner. (2019). Gartner 2019 Hype Cycle for Blockchain Business Shows Blockchain Will Have a Transformational Impact across Industries in Five to 10 Years. *Gartner*.
- Gavard-Perret, M. L., Gotteland, D., Haon, C., & Jolibert, A. (2008). *Méthodologie de la recherche*. Pearson Education France.
- Ghosh, E., & Das, B. (2019). A Study on the Issue of Blockchain’s Energy Consumption. Dans E. Ghosh, & B. Das, *Advances in Intelligent Systems and Computing*. Singapore: Springer.

- Granetto, B., Kandaswamy, R., Lovelock, J., & Reynolds, M. (2017). Forecast: Blockchain Business Value, Worldwide, 2017-2030. *Gartner*.
- Gupta, V. (2017, February). A brief history of Blockchain. *Harvard Business Review*.
- Haidar, F., Kaiser, A., Lonc, B., Urien, P., & Denis, R. (2018). C-its use cases: Study extension and classification methodology. *Proc. IEEE 87th Veh. Technol. Conf. (VTC Spring)*.
- Hart, R. (2017, July 10). *If you're not a White Male, Artificial Intelligence's Use in healthcare could be Dangerous*. Retrieved from Quartz: <https://qz.com/1023448/if-youre-not-a-white-male-artificial-intelligences-use-in-healthcare-could-be-dangerous/>
- Hawking, S. (2018). *Briefs Answers to The big Questions*. United States: Hodder & Stoughton.
- Herweijer, C., Waughray, D., & Warren, S. (2018). *Building block(chain)s for a better planet*.
- Iliashenko, O., Bikkulova, Z., & Dubgorn, A. (2019). Opportunities and challenges of artificial intelligence in healthcare. *EDP sciences*.
- Ilinca, D. (2020). *Digital Health Entrepreneurship*. Vancouver: Springer Nature Switzerland.
- Imbert, G. (2010). L'entretien semi-directif : à la frontière de la santé publique et de l'anthropologie. *Recherche en soins infirmiers*, 102(3), pp. 23-24.
- Intersoft Consulting. (n.d). *Art. 17 GDPR Right to erasure ('right to be forgotten')*. Retrieved from Intersoft Consulting: <https://gdpr-info.eu/art-17-gdpr/>
- Janson, V., Merkle, D., & Middendorf, M. (2008). A decentralization approach for swarm intelligence algorithms in networks applied to multi swarm PSO . *International Journal of Computational Intelligence Systems*.
- Jiang, F., Jiang, Y., Zhi, H., Li, H., Ma, S., Wang, Y., . . . Wang, Y. (2017). Artificial intelligence in healthcare: past, present and future. *Stroke and Vascular Neurology*.
- Johnson, R., Onwuegbuzie, A., & Turner, L. (2007). Toward a Definition of Mixed Methods research". *Journal of Mixed Methods Research*, 1(2), 112-133.
- Kemp, L. (2020, October 27). *How can we solve the blockchain conundrum?* Retrieved from OECD on the level: <https://oecdonthellevel.com/2020/10/27/how-can-we-solve-the-blockchain-conundrum/>
- King, S., & Nadal, S. (2012). PPCoin: Peer-to-peer crypto-currency with proof of stake. *Tech. Rep*.

- Koch, M. (2018). Artificial intelligence is becoming natural,. *Cell*.
- Krittanawong, C., Rogers, A. J., Aydar, M., & Choi, E. (2020). Integrating blockchain technology with artificial intelligence for cardiovascular medicine. *Nature Review Cardiology*, 17.
- Kwon, J. (2014). *Tendermint: Consensus Without Mining*.
- Leloup, L. (2017). *Blockchain: La révolution de la confiance*. Paris: Groupe Eyrolles.
- Lincoln, Y. (1995). Emerging criteria for quality in qualitative and interpretive research. *Qualitative Inquiry*, 275-289.
- Loignon, S. (2017). *Big Bang Blockchain: La seconde révolution d'internet*. Paris: Tallandier.
- Longoni, C., Bonezzi, A., & Morewedge, C. K. (2019). Resistance to Medical Artificial Intelligence. *Journal of Consumer Research*.
- Maddox, T., Rumdfeld, J., & Payne, P. (2018). Questions for Artificial Intelligence in Healthcare. *JAMA*.
- Magazzeni, D., McBurney, P., & Nash, W. (2017). Validation and verification of smart contracts: A research agenda. *Computer*.
- Malets, D. (2019). *Why Blockchain for Electronic Medical Records (EMR) is an Industry Game Changer*. Retrieved from Technorely: <https://technorely.com/emr-using-blockchain/>
- Mamoshina, P., Ojomoko, L., Yanovich, Y., Ostrovski, A., Botezatu, A., Prikhodko, P., . . . Zhavoronkov, A. (2018). Converging blockchain and next-generation artificial intelligence technologies to decentralize and accelerate biomedical research and healthcare. *Oncotarget*, 9.
- Mannini, A., Trajaniello, D., Cereatti, A., Sebatina, A. (2016). *A machine Learning Framework for Gait classification using inertial sensors: application to Elderly, Post-Stroke and Huntington's Disease Patients*. *Sensors*.
- Marr, B. (2018). Artificial Intelligence and blockchain: 3 Major Benefits of Combining These Two Mega-Trends. *Forbes*.
- Marwala, T., & Xing, B. (2018). Blockchain and artificial intelligence.
- Mayo Clinic. (2020). *Diabetic retinopathy*. Récupéré sur Mayo Clinic: <https://www.mayoclinic.org/diseases-conditions/diabetic-retinopathy/symptoms-causes/syc-20371611>
- McKinsey & Company. (2020). *Transforming healthcare with AI*. EIT Health.

- McMahan, H., Moore, E., Ramage, D., Hampson, S., & Arcas, B. (2018). Communication-efficient learning of deep networks from decentralized data. *The 20th International Conference on Artificial Intelligence and Statistics*.
- Mesko, B., Hetenyi, G., & Gyorffy, Z. (2018). Will artificial intelligence solve the human resource crisis in healthcare? *BMC Health Services Research*.
- Microsoft. (2018). *Healthcare, Artificial Intelligence, Data and Ethics - a 2030 vision*.
- Mohri, M., Rostamizadeh, A., & Talwalkar, A. (2018). *Foundation of machine learning*. London: The MIT press.
- Mougayar, W. (2016). *The Business Blockchain: promise, practice, and application of the next internet technology*. New Jersey: John Wiley & Sons.
- Moulinsard, E. (2020, February 4). *Premier avion - Histoire de l'aviation*. Retrieved from Histoire pour tous: <https://www.histoire-pour-tous.fr/inventions/2710-invention-avion.html>
- Mrazek, M., & O'Neill, F. (2020). Artificial Intelligence and Healthcare in Emerging Markets. *International Finance Corporation*.
- Muchielli, A. (2009). *Dictionnaire des méthodes qualitatives en sciences humaines et sociales* (Vol. 3). Paris: Armand Colin.
- Murphy, K. (2012). *Machine Learning, a probabilistic perspective*. London: The MIT press.
- Nakamoto, S. (2014). *Bitcoin: A peer-to-peer electronic cash system*. Retrieved from <https://bitcoin.org/bitcoin.pdf>
- NBAI. (2018). *Decentralized AI blockchain Whitepaper*. Nebula AI Team. Montréal: Nebula AI inc.
- Niforos, M. (2019). Bridging the Trust Gap: Blockchain's Potential to Restore Trust in Artificial Intelligence in Support of New Business Models. *International Finance Corporation*.
- OECD. (2019). *Health inequalities*. Retrieved from OECD better policies for better lives: <https://www.oecd.org/health/inequalities-in-health.htm>
- Paillé, P., & Mucchielli, A. (2012). *L'analyse qualitative en sciences humaines et sociales*. Armand Colin.
- Panarello, A., Tapas, N., Merlingo, G., & Puliafito, A. (2018). Blockchain and IoT integration: A systematic survey. *Sensors*.
- Patterson, D. (1990). *Introduction to Artificial Intelligence and Experts systems*. New Jersey: Prentice.

- Petre, A., & Haï, N. (2018). Opportunités et enjeux de la technologie blockchain dans le secteur de la santé. *Médecine/Sciences*.
- Plant, R. (1994). *An introduction to artificial intelligence*. Miami: University of Miami.
- Prabhu. (2018, May 4). *Understanding of Convolutional Neural Network (CNN) — Deep Learning*. Récupéré sur medium: <https://medium.com/@RaghavPrabhu/understanding-of-convolutional-neural-network-cnn-deep-learning-99760835f148>
- Protenus. (2017). *2017 Breach Barometer Annual Report*.
- PwC. (2017). *What doctors? Why AI and Robotics will define new health?* Retrieved from : <https://www.pwc.com/gx/en/industries/healthcare/publications/ai-robotics-new-health/ai-robotics-new-health.pdf>
- PwC. (2018). *Global Blockchain Survey 2018*. PwC. Retrieved from : <https://www.pwc.com/gx/en/industries/technology/blockchain/blockchain-in-business.html>
- PwC. (2020a). *Santé: Les médecins de demain seront-ils des machines à tout faire?* Retrieved from : <https://www.pwc.fr/fr/decryptages/transformation/sante-les-medecins-de-demain-seront-ils-des-machines-a-tout-faire.html>
- PwC. (2020b, February 20). *Consumers trust your tech even less than you think*. Retrieved from PwC United States: <https://www.pwc.com/us/en/services/consulting/library/consumer-intelligence-series/trusted-tech.html>
- Qi, Y., & Xiao, J. (2018). Fintech: AI powers financial services to improve people's lives. *Communication of the ACM*.
- Reddy, M. (2020). Digital Transformation in Healthcare in 2020: 7 Key Trends. *Digital Authority Partners*.
- Rigby, M. (2019). Ethical Dimensions of Using Artificial Intelligence in Health Care. *AMA Journals of Ethics*.
- Robertson, S. (2018). *What is a neoplasm*. Opgehaald van News Medical Lifesciences: <https://www.news-medical.net/health/What-is-a-Neoplasm.aspx>
- Rosic, M. (2020). *Blockchain Consensus: A Simple Explanation Anyone Can Understand*. Retrieved from BlockGeeks: <https://blockgeeks.com/guides/blockchain-consensus/>
- Salah, K., Rehman, M., Nizamuddin, N., & Al-Fuqaha, A. (2018). Blockchain for AI: Review and Open Research Challenges. *IEEE*.

- Sartorius. (2020, August 18). *What Is Principal Component Analysis (PCA) and How It Is Used?* Retrieved from Sartorius: <https://www.sartorius.com/en/knowledge/science-snippets/what-is-principal-component-analysis-pca-and-how-it-is-used-507186>
- Saunders, M., Lewis, P., & Thornhill, A. (2012). *Research Methods for Business Students*. Pearson Education Limited.
- Sauro, J. (2019, May 7). *10 Things to know about the technology acceptance model*. Retrieved from Measuring U: <https://measuringu.com/tam/>
- Schönberger, D. (2019). Artificial Intelligence in Healthcare: a critical analysis of the legal and ethical implications. *International Journal of Law and Information Technology*, 27, 171-203.
- Sechrest, L., & Sidani, S. (1995). Quantitative and qualitative methods: Is there an alternative? . *Evaluation and Program Planning*, 18, 77-87.
- Sedlmeir, J., Buhl, H., Fridgen, G., & Keller, R. (2020). The Energy Consumption of Blockchain Technology: Beyond Myth. *Business & Information Systems Engineering*
- Seong-Kyu, K., & Jun-Ho, H. (2020). Artificial Neural Network Blockchain Technique for Healthcare System: Focusing on the Personal Health Records. *Electronics*, 9.
- Seth, S. (2020, July 14). *What Is a Cryptocurrency Public Ledger?* Récupéré sur Investopedia: <https://www.investopedia.com/tech/what-cryptocurrency-public-ledger/>
- Sharma, T. (2019). *Public VS Private blockchain: a comprehensive comparison*. Retrieved from Blockchain Council: <https://www.blockchain-council.org/blockchain/public-vs-private-blockchain-a-comprehensive-comparison/>
- Shortliffe, E. (1974). A rule-based computer program for advising physicians regarding antimicrobial therapy selection. Dans *Proceedings of the 1974 annual ACM conference*.
- Skalex. (2020). *AI & Blockchain: The Intersection of Top Tech Trends*. Retrieved from Skalex: <https://www.skalex.io/artificial-intelligence-blockchain/>
- Strohm, P. (2018, July 31). *Trending Technologies for BI & Financial Planning and Analysis*. Retrieved from Jedox.: <https://www.jedox.com/en/blog/artificial-intelligence-business-intelligence-fpa-part-2/>
- Suliman, A., Husain, Z., Abououf, M., Alblooshi, m., & Salah, K. (2018). Monetization of IoT Data using Smart Contracts. *IET Networks*.
- The European Commission. (2020). *Ethics guideline for trustworthy AI*. European Commission.

- UNCTAD. (2020, April 06). *Coronavirus reveals need to bridge the digital divide*. Retrieved from UNCTAD: <https://unctad.org/news/coronavirus-reveals-need-bridge-digital-divide>
- Vector. (2018, July 10). *The 70% value of Blockchain lies in the reduction of costs*. Retrieved from Vector: <https://www.vectoritcgroup.com/en/tech-magazine-en/cybersecurity-en/70-of-the-value-of-the-blockchain-lies-in-the-reduction-of-costs/>
- Villar, J., González, S., Sedano, J., Chira, C., & Galan, J. (2015). Improving human activity recognition and its application in early stroke diagnosis. *The International Journal of Neural Systems*.
- Wang, J., Qin, R., & Wang, F. (2018). An overview of smart contract: Architecture, applications, and future trends. *IEEE Intelligent Vehicles Symposium*.
- Woods, J. (2018). *Blockchain: Rebalancing & Amplifying the Power of AI and Machine Learning (ML)*. Retrieved from Medium: <https://medium.com/crypto-oracle/blockchain-rebalancing-amplifying-the-power-of-ai-and-machine-learning-ml-af95616e9ad9>
- Xu, X., Gramoli, V., Pautasso, C., Ponomarev, A., Zhu, L., & Chen, S. (2016). The Blockchain as a Software Connector. *Computer science*.
- Zheng, Z., Xie, S., Dai, H.-N., Chen, X., & Wang, H. (2018). Blockchain challenges and opportunities: a survey. *International Journal of Web and Grid Services*, 14(4).

Appendices

Appendix A. Stroke detection and prevention

In China, stroke is the main death cause and the fifth in North America. For now, AI has already shown good results in prevention and treatment within this research. Symptoms of stroke are difficult to detect and administrating a treatment may be too late sometimes (Jiang et Al., 2017). As a stroke may be detected by a change in human body movement, Villar et al (2015) created a device able to detect when movements are different than the normality by incorporating two algorithms. Mannini et al. (2016) also created a device which collects data extracted and classify them correctly at 90.5%.

Appendix B. Anamnesis and the medical Chabot

People may think that AI will potentially replace physicians. Where machine can be a better analyst, such as radiology, machine may indeed replace human judgment. However, machines will more assist and support physicians than replacing them (Jiang et al., 2017). Indeed, today burnouts increase considerably and AI may help to alleviate doctors with repetitive and non-valuable tasks. A study shows that the number of physicians impacted by burnout increased from 45.5% to 54.4%. One of the problem cited is the proportioned time spent on EMR to the time spent with patient (Alexander & Ballou, 2018).

But, according to Bertalan Mesko (2018), AI may help to tackle the lack of doctors and nurses issue. The WHO says that health professional shortage amounts up to 7 million with the biggest gaps in Africa, South East Asia and Mediterranean region (Coucke, 2017). Therefore, by using voice recognition, which is created by the progress in NLP⁷ or voice recognition by Google or Amazon, a potential application will be the assistant recording a conversation to fill the EMR and help with the anamnesis⁸. It can help at the emergency, to go faster and to follow medical prescription correctly (Ilinca, 2020).

To test the chatbot, the Royal College of Physicians in collaboration with Stanford Primary Care and Yale New haven Health created a test which has been taken by the bot and

⁷ NLP is explained as “extract from the sentence a rich set of hand-designed features which are then fed to a standard classification algorithm”. Those form of AI works with decision trees which help to direct the conversation based on the giving answers (Colyer, 2016).

⁸ When a patient goes to a medical appointment, a semi-structured conversation occurs between the patient and the professional. Those gathered information during the conversation help the doctor to understand the patient’s history and help to discover symptoms to establish a diagnosis. In a nutshell, it is a patient’s historical report (Coucke, 2017).

medicine students. The result was outrageous as the bots obtained 81% while the students' average was 72% (Coucke, 2017). A good example, is Corti, a Danish start-up which has for product a voice-based digital assistant using NLP to understand the patient and which offers a second quality opinion about a patient's condition by analysing, not only words but also voice tone, verbal and non-verbal communication (Corti, 2020). It analyses emergency calls and detect characteristics of cardiac arrest which at 93% are detected by the AI system (McKinsey, 2020). NLP and chatbot can also be used in telemedicine to support the physicians with repetitive tasks (reminders, symptoms triaging, assessments, etc).

Appendix C. Diseases using AI

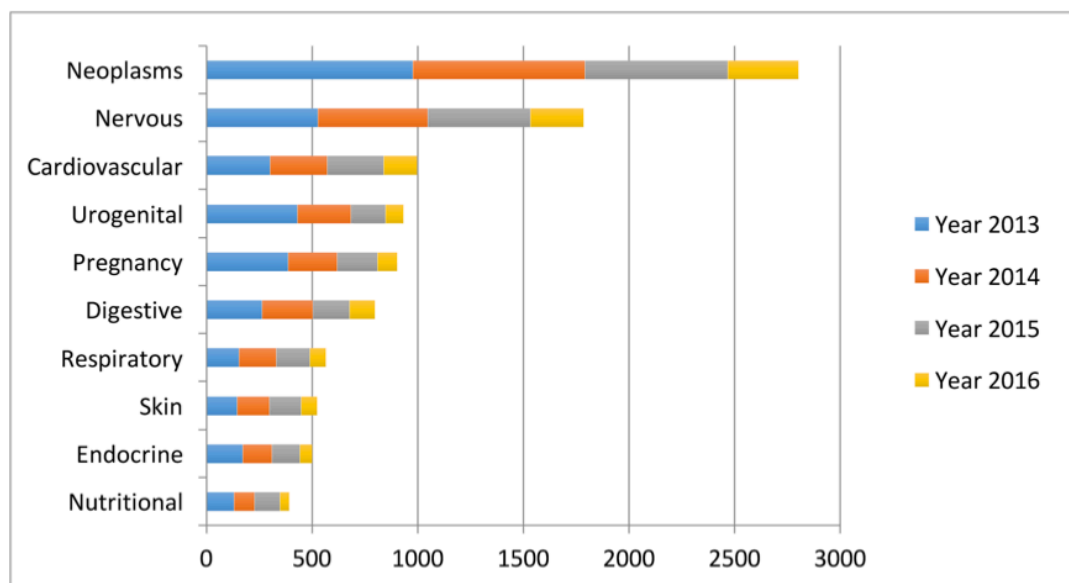


Figure 22: Diseases using AI the most (Jiang et al.,2017)

Appendix D. Ethical framework established by the European Commission

The ethical framework used for the analysis is based on a framework established by the European Commission. Therefore, the only source for this part will be the EU commission (2020). As this is principally true for Europe and not for the rest of the world, we assume that we can expand it to the entire world.

According to the European commission, to reach AI goal such as wellbeing and innovation program, it is important that the technology focuses on human. Indeed, putting AI in the service of humanity must be done while taking risks and challenges into account. For this, the European Commission, with 52 experts focuses on the elaboration of ethics guidelines for the development of a trustworthy AI as well as recommendations in terms of policy and investments in AI. However, as we have seen during the theoretical part, the framework's part which interest us is the ethics guidelines.

For AI to be used, deployed and trusted by companies and people, this one needs to prove trustworthiness. The three cited characteristics for a trustworthy AI are lawful, ethical and robust AI. However, in the EU framework, they do not focus on lawful AI but only on ethical and robust AI which have a link and complete each other. Indeed, Ethics is primordial to ensure the trustworthiness of AI. When this aspect is meet, robustness intervene as the society needs to be convinced about the system and the fact it is not going to cause involuntary harm.

An important thing to point out is that ethics related to AI is a sub-category of the general ethics as here, it is based on the AI utilisation and development.

The ethics principles presented by the EU commission are based on the fundamental rights. The fourth principles are:

1. Respect for human autonomy

Respect of human's freedom and autonomy is one of the known fundamental rights. The human interacting with machine needs to take part of the process and to keep its autonomy and not be at the mercy of a *black box*. Therefore, machine supervision done by

human is critical and fundamental. In addition, work could be reorganized with AI and those systems should improve the work environment, create more meaningful work.

2. Prevention of harm

AI system should not harm human, even physically or morally. The environment in which the system is evolving need to be secured, robust – technically as well, no subject to misused, etc.

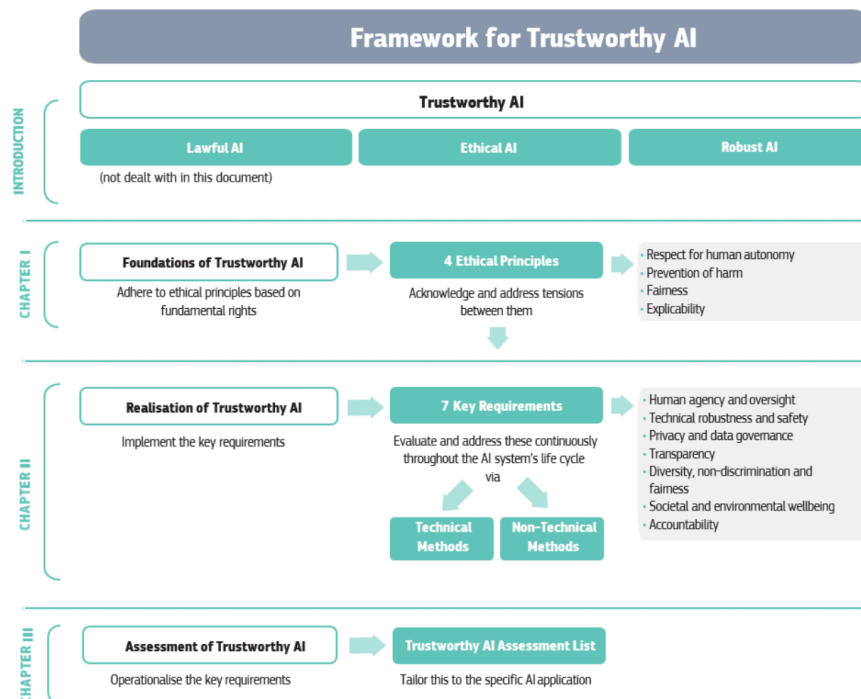
3. Fairness

The use and development of the AI system need to be fair. Individuals should not be subject to discrimination, stigmatisation, or to biases. If this is respected, AI could even participate to the development of a fairer society and equality of chances, either in access to education, goods or technologies.

Moreover, a user has to have the ability to understand how a decision has been taken, to identify this decision and to contest the taken decision trigger a procedure if necessary.

4. Explicability

Explicability is critical for the AI adoption and trust. It means that the system needs to be transparent, that the capacity and purposes of AI is known and well communicated. Finally, the decisions need to be understandable by the direct or indirect users. However, it is difficult sometimes to explain the decision as it is an algorithm or *blac kbox* which came to this result.



Seven requirements have been listed to come to a trustworthy AI, based on the previous characteristics. Those requirements are represented in the figure below.

1. Human agency and oversight:

- a. **Fundamental rights:** AI system can improve the fundamental rights, but it can also have a negative impact.
- b. **Human action:** the users should have autonomy and be able to contest an AI decision. They should have knowledge and tools to understand how the AI system is working. Moreover, the AI system should help the user to take better decisions.
- c. **Human control:** the human control helps to avoid AI to take the lead and to reduce the human's autonomy. Therefore, 3 ways of controlling the AI machine exist:
 1. **Human in the loop:** the human intervenes in all steps of the process – which is almost impossible
 2. **Human on the loop:** Human intervenes in the system conception phase and monitors the system operation
 3. **Human in command:** Human is controlling global activity of the AI system

The less control a human has, the more governance and legal aspect need to be reinforced.

2. **Technical robustness and safety:** It gathers attacks, security and reliability and aim to prevent risk and reduce unwilling events
 - a. **Attacks and security:** The AI system should be protected against hacking which could attack data, models or infrastructure.
 - b. **General security:** The system should have backups in case something goes wrong. AI could go from a statistical system towards a system based on rules or could ask a human permission before going to the next step. We must be sure that the system will not take actions that could cause harm to human.
 - c. **Accuracy:** Accuracy is the capacity to have a correct judgment, to take good decisions. If a high degree of accuracy cannot be obtained, it is important to enounce the probability an error can occur. It is especially important in the AI which have a direct impact on human's life.
 - d. **Reliability and reproducibility:** AI results need to be reproducible, and reliable.
3. **Privacy and data governance:** Respect of the private life, data integrity, quality and accessibility
 - a. **Privacy and data protection:** AI system should respect privacy as well as data governance during the AI lifecycle. It concerns information given by the users as well as the information generated by the system. For the users to trust the system, they need to know that the information won't be used against them, in a discrimination or illegal way.
 - b. **Quality and integrity of data:** Data quality is important for the use of AI. Data collection can be subject to some bias such as social, errors or mistakes biases. It must be considered before using the AI system based on those data. Using biased data for AI training may biased the results or the behaviour.
 - c. **Access to data:** protocols about data accessibility should be put in place to see you should have access to those data and in which circumstances.

4. **Transparency:**

- a. **Traceability:** The data use, algorithms, the data collection process, etc must be accessible and documented based on strict norms to allow the traceability as well as a transparency improvement.
- b. **Explainability:** It is related to the ability of explaining technical processes as well as human decisions based on them. The technical decision done by AI need to be traced and available for human.
- c. **Communication:** Human has the right to know when they do not interact with a human but with an AI system.

5. **Diversity, non-discrimination and fairness:**

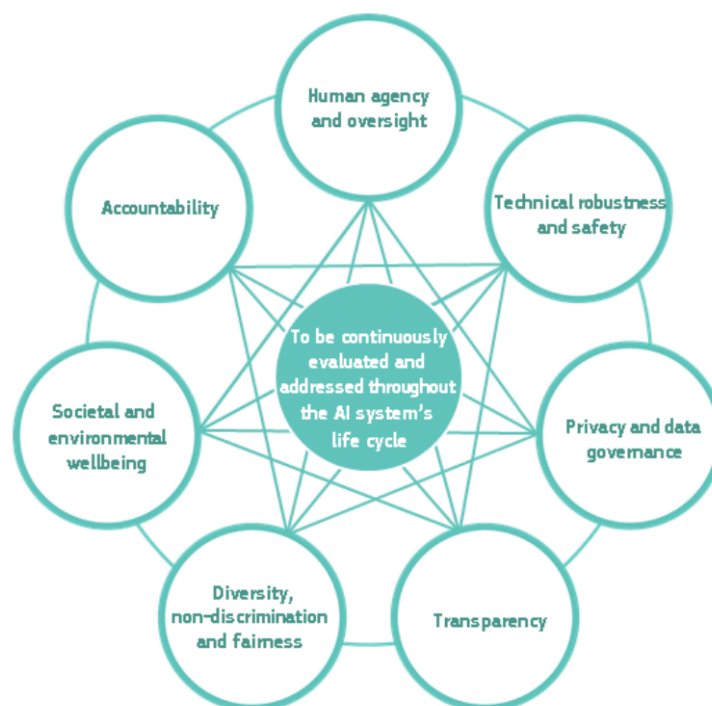
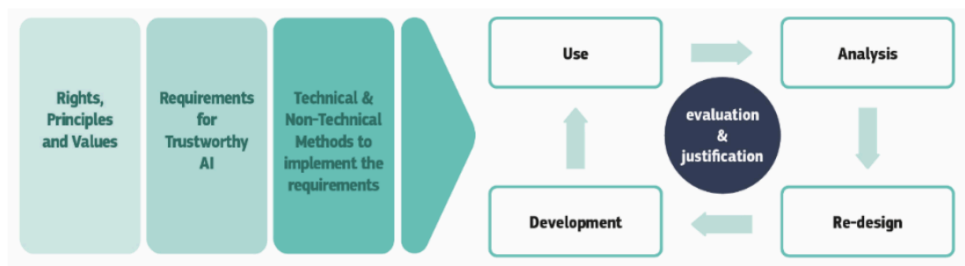
- a. **Avoidance of unfair bias:** Data which are used for AI can be biased by other parties, unwillingly or not. Those biases could lead to discrimination and unwilling prejudices against group of people.
- b. **Accessibility and universal design:** The AI system should be accessible to everyone without considering the age, gender, etc. It can increase equity.
- c. **Stakeholders participation:** To create a trustworthy AI, it is important to consult the different stakeholders which will be impacted by the systems.

6. **Societal and environmental wellbeing:**

- a. **Sustainable and environmental friendly AI:** It is important that AI is eco-friendly. Therefore, the processes need to be evaluated to assess the energy consumption, etc.
- b. **Social impact:** AI systems could be great for society but could also deteriorated them.
- c. **Society and democracy:** The impact of AI on society and democracy has to be taken into account

7. **Accountability:** auditability, legal procedures

- a. **Auditability:** This is the possibility to evaluate algorithms, data and processes. Evaluation by external or internal auditor and the availability of the report can increase the system reliability.
- b. **Minimisation of negative impact:** It is important to document the action and decision taken as well as answering questions about the consequence of an obtained result.
- c. **Trade-offs:** Some trade-offs could be done with reason and method, to be elaborated and analysed.
- d. **Redress:** It is important to give the possibility to user to appeal against a decision or when something goes one. Knowing that it is possible may increase the trust in AI.



Appendix E. Sources of data in Healthcare

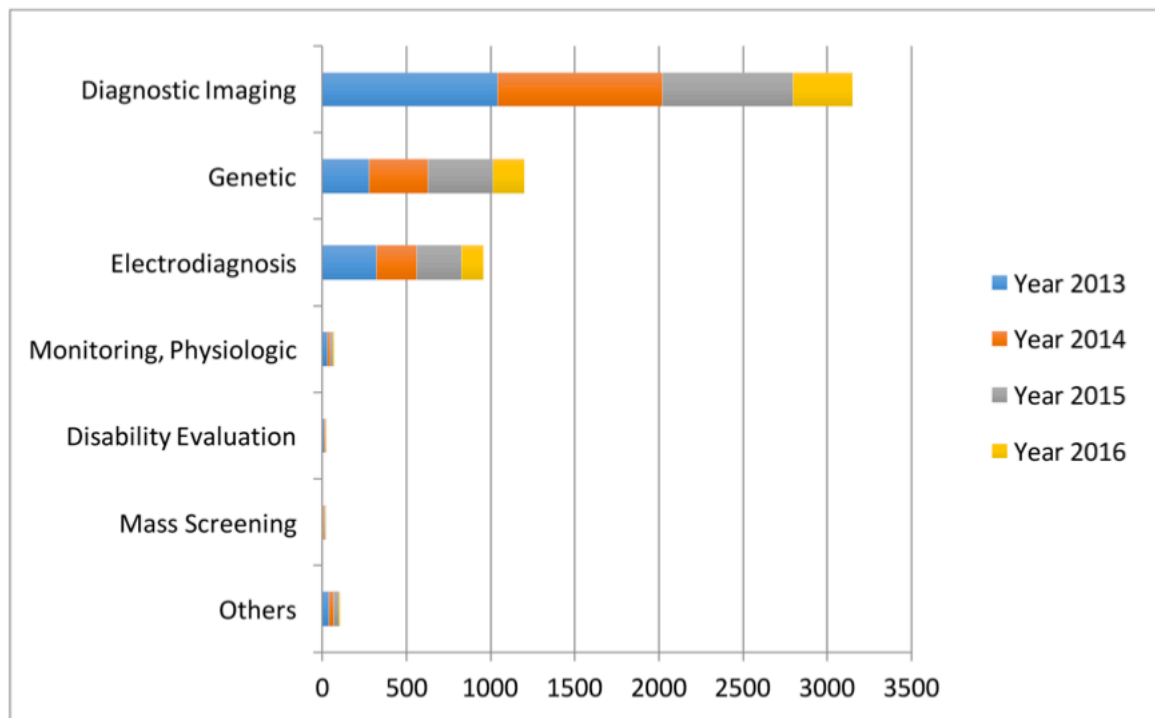


Figure 23: Sources of data in healthcare (Jiang et al.,2017)

Appendix F. Business Value-add of Blockchain by 2030: \$3.1 Trillion by 2030

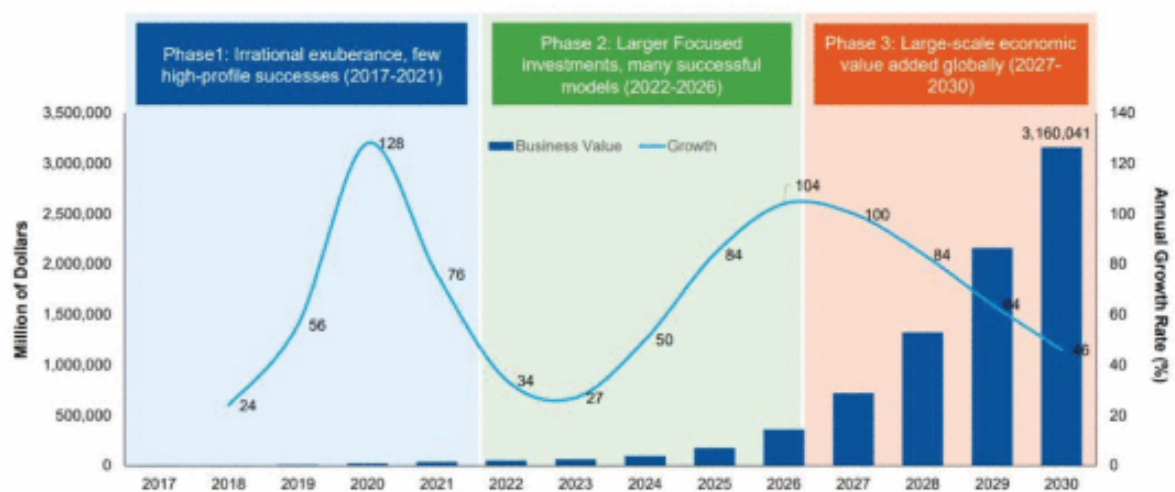


Figure 24: Business Value-add of Blockchain by 2030: \$3.1 Trillion (Gartner, 2019)

Appendix G. Illustration of Blockchain use with Alice & Bob

When, Alice sends something to Bob, she encrypts the hash value using her private key. Bob receives it and will verify that Alice's hash function is the same as the one she encrypted with the original data. Thanks to his public key, Bob will be able to access the data Alice sent to him (Zheng et al., 2018). After the transaction occurs, everyone can verify that the information has been placed and by who. However, only the header of the transaction is publicly available, only the owner of the private key can access what is really inside this information. In addition, for a digital asset to be encrypted in the blockchain, it needs to have a specific right to use and a value attached to it. Without it, it is just a digital file and not an asset – it can be a song, a logo, a book, etc. It becomes *smart* once it is linked to the blockchain with a digital fingerprint (Mougayar, 2016).

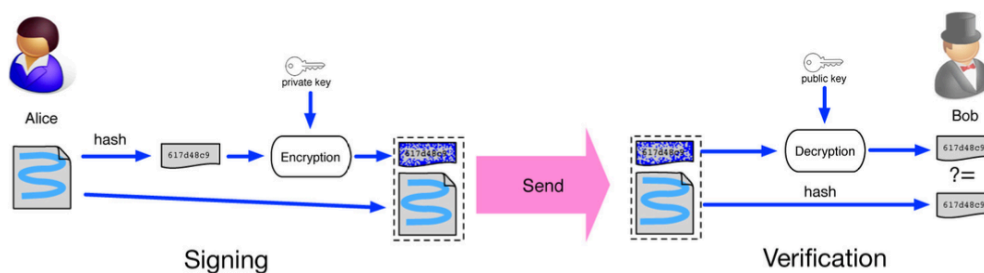


Figure 25: Transaction between Bob and Alice (Zheng et al., 2018)

Appendix H. Consensus Protocol

Platform	PoW	PoS	BFT	PoAc	PoB	PoET	PoC	PoA	PoI
Achain [70]	✓	✓	✓	✗	✗	✗	✗	✗	✗
Alfa-Enzo [97]	✗	✗	✗	✓	✗	✗	✗	✗	✗
Ardor [71]	✗	✓	✗	✗	✗	✗	✗	✗	✗
Azure Blockchain Workbench [72]	✗	✗	✗	✗	✗	✗	✗	✓	✗
Bitcoin [4]	✓	✗	✗	✗	✗	✗	✗	✗	✗
Blocko CoinStack [73]	✓	✗	✗	✗	✗	✗	✗	✗	✗
BurstCoin [98]	✗	✗	✗	✗	✗	✗	✓	✗	✗
Chain Core [74]	✗	✗	✗	✗	✗	✗	✗	✓	✗
ChainKit by Pencil Data [75]	✓	✗	✗	✗	✗	✗	✗	✗	✗
Corda [76]	✗	✗	✓	✗	✗	✗	✗	✗	✗
Credits [77]	✗	✓	✓	✗	✗	✗	✗	✗	✗
Eos.io [79]	✗	✓	✓	✗	✗	✗	✗	✗	✗
Ethereum [11]	✓	✓	✗	✗	✗	✗	✗	✗	✗
HydraChain [80]	✗	✗	✓	✗	✗	✗	✗	✗	✓
Hyperledger [81]	✗	✗	✓	✗	✗	✓	✗	✗	✗
IOTA Tangle [82]	✓	✗	✗	✗	✗	✗	✗	✗	✗
Multichain [83]	✓	✗	✗	✗	✗	✗	✗	✗	✗
NEM [99]	✗	✗	✗	✗	✗	✗	✗	✗	✓
Nxt Blockchain [71]	✗	✓	✗	✗	✗	✗	✗	✗	✗
Quorum [84]	✗	✓	✓	✗	✗	✗	✗	✗	✗
SAP Leonardo [85]	✓	✗	✓	✗	✗	✓	✗	✗	✗
SlimCoin [94]	✗	✗	✗	✗	✓	✗	✗	✗	✗
Stratis [86]	✓	✓	✗	✗	✗	✗	✗	✗	✗

Figure 26: The used protocol by different platforms (Salah et al., 2018)

Appendix I. Proof-Of-Work (PoW)

PoW is the most used consensus model, especially in the permission-less network. Some miners who hold a powerful and enough computational power will verify the transaction by mining it (Herweijer, Waughray, & Warren, 2018). It means that a puzzle or a cryptographic operation has to be resolved and it produces a value. The difficulty increases every 2016 blocks and at least 51% of the network has to participate (Loignon, 2017). Once a node finds the value, it sends it to the network where the other nodes must confirm the value (Zheng et al., 2018; Salah et al., 2018). It takes approximately 10 minutes to operate. Within this timeframe, it is almost impossible that another block has been generated (Crosby and al., 2016). But, if two nodes find the solution – what is called a fork situation – the longest chain is kept (Zheng et al., 2018). To keep this chain, the network analyses which of the nodes has made the maximum amount of work. However, this fork situation takes too much time (Ali Syed, 2019).

The PoW is slow and becomes even slower – 7 seconds per transaction – and it will escalate with the number of users that increases. It is really costly, energy-intensive and more attacks may happen because of the opening access (Herweijer, Waughray, & Warren, 2018). It may therefore compromise the AI application which may be deadly for healthcare use (Salah et al., 2018). Therefore, it may be a bottleneck for AI application as the algorithm updates decisions all the time, it creates high frequency in AI.

In addition, if the PoW is used for example, the difficulty of the mining process increases every 4 hours which requires more computational power, and therefore, more energy in order to compete (Herweijer, Waughray, & Warren, 2018). And this mining is 70% done in China – where tools and energy are less expensive – and uses coal-fired power stations which are really polluting as coal is known as being the most carbon-intensive fossil fuel we can find (Loignon, 2017; Denchak, 2018). That is why a more sustainable solution have to be found before blockchain is expanded globally and faces an increase in adoption (Herweijer, Waughray, & Warren, 2018). For example, Ethereum is using PoS which is less energy-intensive – 12-14 times less than PoW. This energy consumption reduction comes from the fact that PoS consensus protocol is based on the resource of capital of the validator and not the computation resource used in the PoW system (Sedlmeir et al., 2020).

Appendix J. Proof-Of-Stake (PoS)

In PoS, people or nodes have to proof their ownership with the amount of currency they possess (Herweijer, Waughray, & Warren, 2018). The validators are randomly selected – delegated, high users – but need to own native currency. This system helps to increase safety as anonymous validators cannot operate as they do not possess native money (King & Nadal, 2012). This simple requirement comes from the fact that people with more money do not have any purpose of hacking the system as a lot of their money is at stake. However, this system is quite unfair as the richest person in the system may dominate the network (Herweijer, Waughray, & Warren, 2018). In addition, the one who tries to cheat is financially fined (Loignon, 2017). This consensus model is easier, less energy-intensive, faster and depends on the existing share a user may possess in term of currency (King & Nadal, 2012).

Appendix K. Art.17 GDPR Right to erasure ('right to be forgotten')

"The data subject shall have the right to obtain from the controller the erasure of personal data concerning him or her without undue delay and the controller shall have the obligation to erase personal data without undue delay where one of the following grounds applies:

1. the personal data are no longer necessary in relation to the purposes for which they were collected or otherwise processed;
2. the data subject withdraws consent on which the processing is based according to point (a) of Article 6(1), or point (a) of Article 9(2), and where there is no other legal ground for the processing;
3. the data subject objects to the processing pursuant to Article 21(1) and there are no overriding legitimate grounds for the processing, or the data subject objects to the processing pursuant to Article 21(2);
4. the personal data have been unlawfully processed;
5. the personal data have to be erased for compliance with a legal obligation in Union or Member State law to which the controller is subject;
6. the personal data have been collected in relation to the offer of information society services referred to in Article 8(1).

Where the controller has made the personal data public and is obliged pursuant to paragraph 1 to erase the personal data, the controller, taking account of available technology and the cost of implementation, shall take reasonable steps, including technical measures, to inform controllers which are processing the personal data that the data subject has requested the erasure by such controllers of any links to, or copy or replication of, those personal data.

Paragraphs 1 and 2 shall not apply to the extent that processing is necessary:

1. for exercising the right of freedom of expression and information;
2. for compliance with a legal obligation which requires processing by Union or Member State law to which the controller is subject or for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller;

3. for reasons of public interest in the area of public health in accordance with points (h) and (i) of Article 9(2) as well as Article 9(3);
4. for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes in accordance with Article 89(1) in so far as the right referred to in paragraph 1 is likely to render impossible or seriously impair the achievement of the objectives of that processing; or
5. for the establishment, exercise or defence of legal claims” (Intersoft consulting, n.d)

Appendix L. Patient's record – Electronic Medical Records – transfer

In 2017, 477 incidents occurred where 74% are the result of hacking or insiders and more than 3.5 million of EMR have been compromised in 2018 (Protenus, 2018). With blockchain, EMR would be stored on a public ledger and not compromised (Ilinca, 2020). MedRec project has already piloted it by giving access to the patient and storing information off-blockchain, with only the signature present on it (Ekblaw et al., 2016).

In addition, in some countries, when we go to hospital, doctors must send personal information to other professionals to know patients' historical data which is costly and time consuming (Ali Syed, 2019). Electronic medical records – EMR – are obsolete and the important data about a patient do not appear somewhere in a structured way. Only few professionals take the lead and try to make something structured and available for future use with quantitative, boolean and qualitative data. However, with blockchain, every stakeholder can have access to medical file as the blockchain system allows to share information with the signature of the patient and the related stakeholders (Leloup, 2017). This is done in a safe way as information is encrypted and able to be send only by the owner of that information. It also increases the accuracy as that information will be timestamped and allow physician to know what prescription from other doctors the patient had, when and this, in a rapid way (Petre & Hai, 2018).

Moreover, a difference from current EMR is that, using blockchain will help researchers to access anonymized data for studies and will help to have better insights about treatment and diseases. Moreover, with the real-time accessibility, a doctor would be able to analyse current patient's information such as diet, exercise or vital signs before a surgery for example, without the need of a real face-to-face consultation. It could also help doctors to give tailored recommendation to patient via an app (Malets, 2019).

Appendix M. Patient's monitoring

The patient health monitoring is also important. Ethereum based system which uses smart contract may help to monitor patients from distance and to send information to health professionals or every stakeholder who needs that information (Loignon, 2017).

If a patient is diagnosed with diabetes, he interacts with a specialist who will send him to a nutritionist, then to other specialists and the data stored on the wearable devices such as insulin need to be sent to different parties. If an error is done, it will not necessarily be noticed. Blockchain can solve those issues. By using smart contract, it could send a lab request and notify a doctor by asking a consult if a diagnosis has been done. And this, by keeping the patient informed (Ilinca, 2020).

Appendix N. Blockchain's benefits

Key Elements	Functionality Description
Decentralized	A database system with open access control to anyone connected to the network. The data can be accessed, monitored, stored, and updated on multiple systems.
Transparent	The recorded and stored data on blockchain is transparent to potential users, which can be further updated easily. The transparent nature of blockchains could certainly prevent data from being altered or stolen.
Immutable	The records, once stored, become reserved forever and cannot be modified easily without having control of more than 51% of the node concurrently.
Autonomy	The blockchain system is independent and autonomous, meaning that each node on the blockchain system can access, transfer, store, and update the data safely, making it trustworthy and free from any external intervention.
Open Source	The blockchain technology is formulated in a way that provides an open source access to everyone connected to the network. This inimitable versatility entitles anyone, not only to check the records publicly, but also develop various impending applications.
Anonymity	As data transfer occurs between node to node, the identity of the individual remains anonymous, thus making it a more secure and reliable system.

Figure 27: Blockchain's Benefits (Ali Siyal et al., 2019)

Appendix O. Blockchain's opportunities & Challenges

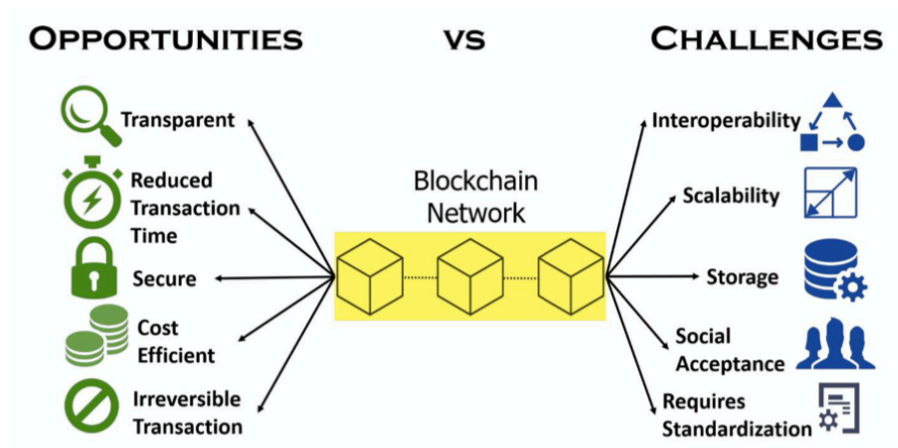


Figure 28: Blockchain's opportunities & Challenges (Ali Siyal et al., 2019)

Appendix P. AI issues and blockchain solution - Convergence

<i>AI issues</i>	<i>Privacy & Cybersecurity</i>	<i>Governance & Legal</i>	<i>Discrimination & Biases</i>	<i>Trust</i>	<i>Transparency & Explainability</i>	<i>Data accessibility</i>	<i>Data integrity, provenance & traceability</i>
<i>Blockchain benefits</i>							
<i>Immutability</i>	X		- Providing immutable, solid consensus mechanism as well as secure and decentralized identity can only be beneficial for ML improvement. It can help with biases, trustworthiness and attacks.	- Blockchain can help to ensure that data are shared if the user wants to and to ensure that our data are not compromised. - Blockchain can help as an audit tool as it can monitor every steps that have taken place.	- Blockchain can help as an audit tool as it can monitor every steps that have taken place and check the provenance of the data which are fed into the AI model. Taken decisions can be easily audited as everything is registered on blockchain and with confidence that it has not been tampered.		- Blockchain can help as an audit tool to check the provenance of the data that goes into the AI model. - With the sensitivity of the healthcare personal data, blockchain is more than welcomed as it is immutable, time-stamped and almost impossible for information to be leaked. With blockchain, the creation of persistent, unalterable, permanent record of documents, data and transactions are now possible.
<i>Auditability</i>	X	- Taken decisions can be easily audited as everything is registered on blockchain, in a transparent way and with confidence that it has not been tampered. Therefore, it may be easier to determine who is at fault if something happens.		- As being a trusted platform where data are safe and secure, blockchain allows AI to take better and more reliable decisions based on data stored on blockchain, without intermediaries and increases trust in AI system.			
<i>Privacy</i>	- The collected and stored data					- Blockchain provides	

Anonymity	stored data based on blockchain maintain the user's privacy and anonymity while being able to use them for feeding AI system					transparency over data. Therefore, with the integration of AI and blockchain, users will share their information as blockchain is secure, transparent and identity is anonymous.
Transparency & Traceability		X	- Blockchain can help with the bias aspect as if something weird or unusual happens, the blockchain technology helps discovering the source of this bias.	- If consumers cannot see from where a decision comes from, it may be difficult for them to trust the results and the actions taken by AI. Thanks to blockchain, it is showed that the data used have not been tampered and it increases the trust in decision making.	- Integrating these two may enhance AI explainability as we can trace ML decisions and therefore help having a better understanding and confidence in AI's decisions.	- We do not have any guarantee that the used data fed in AI machine are trustworthy and blockchain gives that satisfaction and transparency as data are secured in the public ledger and cannot be changed or altered.
Security						- ML works better with accurate, reliable, stable, and trusted data or information to provide good final decision which can be provided by blockchain as this technology relies on integrity and resiliency as information is cryptographically signed and approved by every actor.
Integrity						
Distributed system				- It improves trust and provides accurate outcomes thanks to a large number of autonomous actors.		- Data duplication, transfer and protection can be enhanced with blockchain providing structuring, qualifying data and giving access to personal data to the end user by identification and keys.

Figure 29: AI and blockchain together (from the author, 2020)

Appendix Q. Biomedical researches

In biomedical researches, patients' empowerment and predictive analysis - and in the healthcare sector in general - has already been analysed. AI technology is well known for accelerating and increasing the result accuracy while blockchain can provide a secure and valuable personal data (Mamoshina et al.,2019).

AI-blockchain based system can improve data quality and acquisition. With AI, the patients can upload their data immediately on the system and as they are in fully possession of their own data thanks to blockchain, they grant permission for data usage by receiving money in exchange. Therefore, patients will be able to follow their data usage and be aware of where they are going (Mamoshina et al.,2019).

Appendix R. Healthcare assistant

As the number of care assistant decreases but the demand in elder care increases, assisting robot is a promising technology which will appear in the - near - future. The integration of a communication interface and the identification of ill patients/elders' needs may help to motivate the patient, to help with exercise and reduce their stress.

Appendix S. Interview questionnaire

Interview

Part1: Introduction

- Can you introduce yourself?
- What is your link with Blockchain, AI and what is your relationship with Healthcare?

Part2: Blockchain

- How would you define Blockchain?
- According to you, what are the most important issues Blockchain implementation and adoption is facing in the healthcare sector?
- What are the benefits of blockchain?
- As health data are sensitive, is it better to use a private or a public blockchain?
- If a patient wants to share his data, how his identity may be protected, and the privacy maintained?

Part3: Artificial Intelligence problems

- How would you define AI?
- What are the challenges AI is facing (Ethically and technologically)?
- AI technology is facing problems such as: (will explain it orally)
 - Governance & legal
 - Privacy & Cybersecurity – privacy of data's owner and gathering them.
 - Discrimination and biases
 - Trust issues from patient or doctors
 - Transparency and explainability
 - Data quality, availability and provenance

Part4: Blockchain and AI together

- ❖ Data management
 - How blockchain can facilitate data accessibility to train AI model?
 - Could data management based on blockchain increase transparency, traceability and allows the use of structured and high-quality data for AI?
- ❖ Trust improvement
 - How blockchain use could help increase the trust in AI decision?
 - Will the patient or doctor trust AI system thanks to blockchain implementation?
 - Does a system where the patient is rewarded for sharing his data is viable?
- ❖ Discrimination and unfair biases
 - Can unfair biases as well as discrimination be reduced with blockchain?
- ❖ Explainability and transparency

- As everything can be registered on the ledger, may it help to explain the reason a certain decision has been taken? Can it help increasing trust?
- Knowing from where the data come from can help the AI system?
- Can it help with liability issue such as who is responsible if something happens?

❖ Issues

- What could be the potential issues preventing the implementation of this two?
- Could scalability issue prevent the blockchain use with AI as this technology requires a lot of data and storage space?

Part5: Technological aspect: Technology acceptance model for Blockchain and AI together.

- Can the integration of both technologies be accepted?
- Would the integration of those systems enhance AI and doctors' job performance? Does it seem useful?
- Would it be easy to use, to implement?
- Do you think that Blockchain use in AI is understandable and clear?
- Do you think that improving blockchain's literacy to people will take time before being able to use it for AI?
- What is your feeling/impression about the implementation of these two?
- What would be your attitude towards this? Would you go for it?
- Do you think that, in the future, these two have the potential and a high probability to end up together?

Appendix T. TAM Model

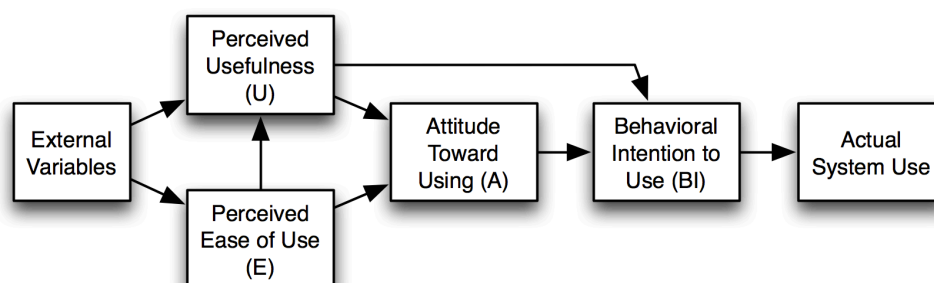


Figure 30: Technology Acceptance Model (TAM) (Sauro, 2019)

According to Sauro (2019), a product needs to be useful and usable to be used and accepted by the population. The perceived usefulness represents the fact that the cited technology is useful and will provide benefits. It represents and answer the question such as : using this technology will help me to perform faster in my job. It is explained by Davis (1989) such as : «The degree to which a person believes that using a particular system would

enhance his or her job performance ».

The ease of use answers questions such as the fact it will be easy to use, operating it will be easy, etc. Davis (1989) uses a 7-point likelihood scale to determine the ease of use and usefulness. He defines it as: «*The degree to which a person believes that using a particular system would be free of effort*».

The ease of use and usefulness revealed being determinants to users' behaviour (Davis, 1989). Indeed, after that, we can evaluate users' attitude towards the technology and determine the use of the system (Allen, 2020).

Appendix U. Professionals' description

Ahmed Banafa – Ahmed Banafa studied at Harvard, MIT and is a professor at St José State University and Stanford where he teaches engineering. He focuses on the Internet-of-Things, blockchain, artificial intelligence and cybersecurity. He wrote several articles published in the IEEE.

Philippe Coucke – Philippe Coucke is the head of the radiotherapy department at the CHU Liège Hospital. He has been interested in new technologies in medicine for a couple of years.

Julian Fifield – Julian studied at the University of Bristol, is a consultant at JRDF Consulting and is a specialist in Business transformation. He shows how new technologies such as blockchain and AI can disrupt traditional industries.

Bill Inman – Bill Inman studied at the University of California and is the CEO of Singularity Studio. He works directly with SingularityNet where they leverage blockchain for AI and create a decentralized AI marketplace. He holds a blockchain patent with a focus on emerging technologies and business innovation.

Hasen Kapasi – Hasen Kapasi is leading and representing the PwC Europe blockchain practice regarding blockchain implementation in different companies such as pharmaceuticals or automotive industries. He is really focusing on the enterprise blockchain side. Before leading the PwC Europe Blockchain, he was working and focusing on IoT and AI.

Robert Miller – Robert Miller studied at the London School of Economics and Political Science. He is currently the director of product management and strategy at ConsenSys Health New York. Besides his work at ConsenSys Health, he writes a lot about emerging technologies, health and data.

Natalia Monteiro – Natalia Monteiro studied business at Durham University Business School. She is manager at CentivaHealth and reviews manuscripts about blockchain as a

service for healthcare. She is passionate about technology, innovation as well as finding solutions to challenging problems.

Jonathan Passerat-Palmbach – Jonathan Passerat is the director, cryptography and decentralised AI at ConsenSys Health. He is a computer scientist and made a thesis regarding high performance and distributed computing. After that, he went to a medical imaging laboratory where they have been using Machine Learning and AI to analyse images. This is where he developed an interest for different technologies such as blockchain.

Tim Richmond – Tim Richmond is a manager at SingularityNet. He has 25 years' enterprise level experience in technology by helping businesses reaching their objectives. He looks for technologies such as AI and blockchain which are beneficial for humanity.

Hubert Ridolphi – Hubert Ridolphi graduated from the University of Strasbourg. He is a pharmacist and science e-health manager at ELCA informatics where he defines and proposes strategies for companies where he handles Life Sciences and E-health digital projects. In 2015, he joined a company which sells middleware, software allowing health data processing. This is where, he implemented blockchain pilot allowing audit trail of the clinical trial for some clients.

Joan Van Loon – Joan Van Loon is an IBM managing director in Belgium and Luxembourg. He is also a member of the board and responsible for the public sector (such as government healthcare, education, etc). In addition, he is a spokesperson for IBM and for everything related to technology in the healthcare sector (AI,...).

Daniel Yasri – Daniel Yasri is a doctor at the CHU Montpellier in France and has been working in blockchain since 2011. He launched two start-upss on the side related to blockchain and healthcare.

Emmanuel Goffi – Emmanuel Goffi is an AI philosophe and the director of the “Observatoire éthique & Intelligence Artificielle” of the Sapiens institute in France. He also

teaches in several universities such as ethics of AI at Aivancity, School for Technology, Business & Society or at Mohammed Premier University in Morocco.

Appendix V. Interviews Transcripts

Interview Ahmed Banafa

Meriyem : Hi Mr Banafa, how are you?

Mr Banafa : Good, thank you very much.

Meriyem : Thank you for joining the call. I will present myself quickly. My name is Meriyem and I am a second year master student in Business Engineering, in Belgium. I am finishing my master with a thesis about how blockchain can impact AI with the precise question which is *"Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence?"*. Could you also introduce yourself, your relation with blockchain and AI as well as with healthcare?

Mr Banafa : I teach, Professor Ahmed, I teach at San Jose State. I teach engineering at San Jose State. I teach also at Stanford University where I teach blockchain. My research is actually focusing on four areas, the IBAC. I called them the IBAC, which is Internet of Things, blockchain, artificial intelligence and cybersecurity. I published a lot of articles about all the four and at the same time, I have two books. One of them is about IoT and the other one is about blockchain. I sent you an article about blockchain and AI this is showing you how they interact with each other. And I look at it from this perspective. The both technologies are really a match. They are the same level. They are not one is weak, the other strong, one strong because each one of them is like a superhero, one of them has certain powers, the other one has certain powers. You talk about the blockchain, talking about immutable records, the data cannot be changed. We can trust it. It's transparent, accessible for everybody. You look at the AI, AI will help us on getting the insight from this data. And just generally speaking, if for the AI itself, which is built on machine learning and deep learning and statistics and all the different mathematical models, the very important concept of garbage in garbage out in statistic, which is if you have a bad data, you enter this one area, you feed this one to this program. And the results will be that something called garbage in, garbage out is a well-known concept in statistic. Blockchain will help with something like this by saying the data itself, which is from hospitals or from supply chain, once you store it on the blockchain, nobody can change it. So technically speaking, you can trust this data. Why? Because you know it's a blockchain, it's not a database. Somebody will give it to you and you can ask what's the integrity of the data. And then you take this data and you clean it. You go with the clinic and then you process it. If somebody told you this came from blockchain system, you will say, OK, now, I can trust this data. I know that nobody modifies it, I can use it without any problem. This is one big advantage. We've seen how the blockchain can help the AI. Blockchain, Generally speaking, as we talk now, they use the consensus protocol, which is called Prove of Work. Proof of work is the building consensus protocol for Bitcoin and Ethereum and all those famous platforms. You solve a mathematical problem, a puzzle which is an encryption. You get to start the blockchain and that takes a lot of power, a lot of time, a lot of graphical

processing units. What if we have an algorithm that will solve this problem in a much easier way instead of consuming all this power we are talking about. That's going to help from that part of the story. The other side is the blockchain can document all the progress of the A.I. You hire me to analyse a big set of data for, let's say, for your retail stores. You own thousands of them in the world and you get this data. You'd like to analyse it. Every time you get a result or you do something with the AI model, you document this one on the blockchain. So later on like two or three months from now, when I get the result, you came to me and ask me, I do not believe this is right. Where did you get this data? Then I can go to the blockchain and I say, OK, at this time, this is the data. This is the result we have. So it's a documentation of the progress of processing the data and getting the insight. So it's just a simple example for both of those.

Meriyem : OK, thank you. So me, I'm focusing especially on how blockchain can help AI. And not the opposite because of course in one paper I can't do both. So that's super interesting. So maybe I can quickly explain how this interview will go. Well, first of all, I have to ask you for your consent to use what we are going to say in my thesis. Is it OK?

Mr Banafa : Absolutely.

Meriyem : OK, perfect. So, first we're going to talk about blockchain. So couple of questions to see how it works, etc. then the artificial intelligence problems that AI is facing today, then how they can go together. And then at the end I'm using the technological acceptance model. I do not know if you know it. It is to see about the acceptance of the technology together, according to you. So maybe we can go to a blockchain first. So you already give a definition of blockchain but maybe you can resume in two or three words. What is it for you?

Mr Banafa : I mean this is one of the toughest stage of dealing with the blockchain. How can you define it? That would be the question. Blockchain can be defined as, first of all, blockchain is a software. So this is going to put everything on the side exactly like AI, AI is a software too. And the best definition I have seen for blockchain is a combination of two things. Cryptography and human logic. So in my book, this is how I define blockchain, is cryptography and human logic. Cryptography means you are encrypting the data. You are using the data in a way where only certain parties will see that one and the people who have certain private key can see that. Human logic is the consensus, the consensus of if one of the nodes and we are talking about thousands of nodes, basically computers have the same copy of the information. If one of them is changed, then through the thinking algorithm, which is something called Glossop protocol, that's the technical name, they can say you're different. We do not want to take that. They just isolate that one. If our government censorship, you know, 20 of the computers in that country, we still have thousands outside that can hold their information. So it's a combination of two things, cryptography and human logic. That's the best definition I have seen so far.

Meriyem : OK, and according to you, what are the most important issues that blockchain implementation and adoption is facing?

Mr Banafa : There are multiple things. Number one is scalability because of the nature of the blockchain that everybody has to agree on this one. So if you have a thousand computers, you have to wait for everybody to agree on this. So you have scalability. You can't scale it up. And also you have the processing power because they have to solve that mathematical problem and the processing time. I'll give you a simple example about what I mean by that. For Visa to process your credit card when you go to any store, the system there, runs twenty-four thousand transactions per second so you do not feel it. Bitcoin, the biggest blockchain network, only runs on seven transactions per second, so you can see twenty-four thousand and seven transactions per second is a big difference. The speed is a problem. The processing power is a problem. And also the you know, the whole thing about, you know, the scalability. Add to this is blockchain is a victim of bad reputation because it's associated with cryptocurrency and cryptocurrency is not a good name in many countries. They associate that one with criminal activities, with ransomware, or the bitcoin, which goes up and down and crashes and at some point people lost their money. And the other thing is the regulation, the regulation itself. And I can send you, all the articles, you know. You know, I'll send you those articles so you can have all this information. I have a nice diagram. The other thing is the regulation, because we do not have enough regulation. Maybe in Europe they are more advanced than United States when it comes to the cryptocurrency. But the United States is very tough for the regulation. It's not approved yet. At the top of that, when you're talking about people, we do not have enough skilled people who know what is blockchain or developed blockchain. When I teach the blockchain, I have a full class because everybody would like to know what it is. And, you know, you go outside, you look at the universities, how many university in the world actually teaching a whole program, of blockchain? You know, it took me months to convince Stanford and convince, you know, San Jose State, just to let me teach the class, because that was in 2018 before we have all this big noise. That is going to be the future, trust me in that. And we do not have enough people to go and teach that to go to work because they have the skills out of that process. So those are the main challenges facing the blockchain.

Meriyem : OK. And then what about the benefits of using it?

Ahmed Banafa : The number one is trust. You know, if the Internet is about connectivity, when are you talking about what we are doing now with the Internet, blockchain is about trust and that trust is actually among people. They do not know each other. I mean, you could be a node on the blockchain. And I never heard about you. And this is the beauty of that one. Number two, it is immutable. It means you cannot change it, so you cannot change it once you have it. It's a software. You enter that information. There's no way for changes because that is the internal structure of the blockchain. You have a block, you have the information, this is going to be encrypted and added to the next block. And so if

I change this one, everything up to this one will be corrupted. Why? Because you cannot change one of them. The only way for you to change whatever inside the blockchain is to have something called soft fork or hard fork. So soft work is a simple thing, like an upgrade. You change the size of the block and hard work is something wrong. If the information is wrong and you want to change it, you just start again. You stop this process, you start again from a different one. That's called the hard work. So it is immutable, it is distributed. There's no centre, you know, computer or people who can attack and shut it down. It is all over the place. So if we have a thousand computers, have the information, if we shut down at two hundred, we still have eight hundred. So that's one important thing. Transparency is there. Transparency is a big word. But last night I was teaching my student at Stanford how to create their own cryptocurrency. And I showed them the transaction. You can see just the encryption and how much they sent, but you do not know who sent it and who received it. You just verify that the transaction is correct. So that transparency is there. It's you know, it gives people some kind of assurance that this transaction is the same as this, the same as this, the same as this. So we can approve it. It's going to go ahead with the process. So this is some of the benefits of blockchain. It's going to apply to everything, not just AI. It can be applied to supply chain, because you know, about the supply chain, if you are sending any kind of food like products or any kind of fruits or vegetables and, you know, it stops at this place, it stops at this place and the weight is this and the temperature in this place it this, if somebody is recording this by hand, they can change it. But if it's recorded on the blockchain and I can access it from here looking at it, I can see that this is why we lost that shipment, because the temperature is really high and it spoiled and it's rotting. So that's why we do this. But if somebody changes it or changes the weight and see, the weight is this and it is more or less. In the system and this is all automated, you scan it and you get it, it's not like you add it by yourself so you can trust it, you can trust that information.

Meriyem : OK, and what about anonymity? Is it also an advantage? Because the person I talked to earlier this afternoon was saying that it was not feasible to remain anonymous.

Ahmed Banafa : OK. It's good, but I think you have to distinguish between two things that are types of blockchain. There is public, there is private and there's hybrid. Private, everybody knows everybody. It's basically, you know, who is this computer, etc, it's easy for you to find. You know, I work with some of the companies here in the Silicon Valley, like Thermo Fisher. And I was explaining to them that you can have five thousands of your employees and you can assign them and you know who they are. So their identity is not going to be exposed. But if it's public, like Bitcoin and Ethereum, you do not know that. Say you have like twenty thousand computers. Who is that person? There is hybrid. Hybrid is a mix of both. You can have some of the information on a private blockchain for you and you can have it on the public where people can access it without knowing who is that person. So the answer is yes and no at the same time.

Meriyem : And as my research is about healthcare, do you think that it's better to use one or the other as the data are sensitive?

Ahmed Banafa : Private is always the case. Just make sure that the number of the nodes is big. That's the whole thing. There is a project call mepasa, which is a project that the United Nation, I'll send you the information, I'm involved with the project, it is in San Francisco. And that one is to have nodes or computers in almost all the hospitals in the world. You know, the main hospitals in the world and the World Health Organization, the United Nation, CDC of the United States and the other countries. So if there are cases for covid-19 like the virus we have now, they just enter it to the computer. They enter that information. And then this information will be in a certain ledger where everybody can access it. And it is another point I want you to keep in mind, Meriyem, there is a concept of smart contract. Smart contract is a very important concept in blockchain. There's no way for you to have a good blockchain system without having a smart contract. That will actually set up some kind of a parameter for you to give you a warning or execute certain actions. For example, if you know, in a certain country the cases went up over a certain threshold, we can design the blockchain with the smart contract. If you see that a certain hospital is registering a thousand cases a day, that will trigger some kind of alert to the World Health Organization. They can go and check everything and they're going to say everybody in this city should stay, should not leave. They're going tell everybody about that. Not waiting for the government to tell order because this alert will go to everybody in the network saying, listen, in certain place, this is what happened. So that is the beauty of using this for health care. I have an article, I'll send it to you two about blockchain and covid-19 how they work together. There are four areas that are actually helping with that one. One of them is a supply chain, the medical supply chain. The other one is the donation, because a lot of people donate for that part. And the third one is the crisis management. We talk about the crisis management; how can you deal with the travel alert for people based on what? It is because some government they shut down the airport. Some of them did not. There are some kind of systems that rely on information. We trust this information because it's in the blockchain and because it's a network that's shared with everybody. Then it's going to be a global alert, saying we're going to ban the travel to this country or this city and we're not going to accept it instead of waiting for political games and all these kind of things going on with that part.

Meriyem : OK, and I also have a question. I was reading in articles that blockchain can help to remove the power from big companies such as the Google, Facebook, Amazon and so on, and give the power into the, for example, in health care, the patient's hands and to monetize their data. How is it possible? How can it work?

Ahmed Banafa : I'm trying to find that article for you. OK, I'm going to put it in the chat for you so you can have that. I'll talk about the big companies and how they are really fighting anything has to do with, you know, with the blockchain. You do not see big projects from those companies. The only big project you can see is Libra from Facebook. That is the

cryptocurrency. You have to understand that the big companies like Google and Facebook and Amazon and you name it all the big companies, they monetize on centralizing and collecting your data. When you have a decentralized, that's what the blockchain is, decentralized data, there's copies everywhere. There's no way for them to make money out of it because there's copies everywhere for it. And they have control on turning on and off using the smart contract. The concept of the smart contract is a very important concept here to say, yes, I give you permission, no, I do not give you permission to do that. And this is how you are going to stop them for this. And they're not happy with it. Trust me. They look at it and they're saying no, and that is why you do not see Google excited about this or Facebook or LinkedIn or Twitter. Twitter yeah, they have a project about it where they can document the information. I know about Apple, they have the timestamp for the activities. They have it in the blockchain because that's going to help them track down any activities. But to use it for the data, you are depriving them from having the data under their control.

Meriyem : OK, so it cannot help to give as a patient, I cannot have my own data and monetize it or can I?

Ahmed Banafa : Yes, I mean, there is a law here in California where they are trying to say, if you want to use my data, you have to pay. And so you can do that. You can have, again, smart contract! You can program that by saying if you use my data, transfer that much money into my account. You can do that. Or transfer it or tell me that you want to inform me about it. And I can talk to you so I can have control on who access it when they access it instead of the concept you have in Europe, which is the GDPR, which is basically with the right to be forgotten, which is you can erase your information on the Internet, but you have to submit a request to Google so they can remove you. It's again, this is centralized. I do not want to do that. I want to have control on my own site where I can just say I do not want anybody to take my data. I want to monetize my data. I want to do this and this. There is actually a company and it is mentioned in the article, I think it is Singularity. I do not know if you've seen it, it's a European company and that company, I encourage you to go to their website because they are really using AI as a service where they can use blockchain and AI. I can give you the exact name for them. They contacted me before the pandemic. They wanted to have an interview with me about the concept. But after the pandemic, everything changed. So many things really cancelled and I haven't heard anything from them. It's called SingularityNet.

Meriyem : Yeah. I'm going to check it. Just for my own comprehension. Now if I want to say, I want my identity to be private, how can I ensure that it will be the case and that the privacy will be respected? I mean, it's through encryption or how is it working with private key?

Ahmed Banafa : Your information, your identity, basically, you're defining your name, your driver license, your birth place, birth date, and all the information will be in a digital

form. That's what blockchain deal with data for. And this one can be encrypted in a way where the smart contract will give somebody access. If you release that one, you say you have a list of agencies. Yes. The police can access it. The government can access it. My parents got access to things like this one. They can access that when they can just show it to them. Other than this, other people, there will be a condition saying "they send a request" to me. They say, can we get this information? You give the permission to do that. Once it is written in that software, which is a form, you fill it and it is online, you fill it and it is part of it, then you will have a complete account control on this. You know, if you have Facebook or if you have any of the social media, you go to privacy, you're going to see those options. You turn them on and off. This is exactly what you are going to do with this. And you can have some block addresses. You can add people, you can block or you can unblock certain people. I do not want this. I do not want to get this information.

Meriyem : OK, thank you. And now maybe I think that we can go to the artificial intelligence part. So what are according to you the issues AI facing in terms of technological and ethical issues?

Ahmed Banafa : OK, before I talk about the issues and the challenges and the benefits of this, we need to define what is AI.

Meriyem : Oh yeah. Right, thank you. I forgot the question.

Ahmed Banafa : Now that's funny because I do this all the time when I start my classes, whatever, I give them a term, I do not want to leave it for their own attention or their own research. I want to be on the same page. So when we talk, we talk about the same thing. So this is what I tell my students. OK, there are three things. There is a machine learning and deep learning. Those are the three terms you have to know and they are interrelated. It is a small circle, which is deep learning, a bigger circle, which is machine learning and the bigger circle, which is AI. And I give them this example, and if you listen to any of my YouTube lectures and I'll send you the link to my channel there, I tell them, think about it this way. Think about AI in this part. Machine learning means you are developing a program. We call it a model. That model will recognize certain inner features or certain activities, finding some kind of a pattern. That's what they are finding a pattern, to do that. So if I have a picture of hundred people, faces of 100 people, and then I wrote a program that will recognize the people who are smiling in those pictures, and then I scan those pictures and the computer will say, OK, five of them are smiling. Why? Because you can define the smile with, you know, how far is the lips and the eyes, and all these. There are certain features. So out of the hundred, the computer found five. This is called machine learning. This is finding people smiling. It got a pattern. Deep learning is why they're smiling. This is a real smile. This is a smile, this is a fake smile. If this is a smile that somebody said it because there's a gun at their head, that's deep learning. When you mix this with this machine learning and deep learning, you get artificial intelligence. So if you have more of deep learning, than machine learning, then you are going to have more in-

depth artificial intelligence that deals with emotions, deals with what's going on with a human being as human. If you have more machine learning programs, then you are dealing with patterns, insights like a business. You just get people buy this one because of this. People buy this one because the people buy this one at this time or that time. So the mix of both of them will give you the artificial intelligence. So that's how we look at the artificial intelligence. The biggest problem of artificial intelligence is the concept of bad data. Eighty percent of the time of the data scientist, the people running the artificial intelligence programs and machine learning, the 80 percent, 80 percent, eight zero percent of their time they spend is cleaning data, which means they look at the data. You know, temperature is twenty-five and suddenly it is two hundred. That makes no sense. You know, people are going to die if it's 200. So you start cleaning the data and the other 20 percent of their time is spent on processing the data. So that is one of the challenge they are facing when it comes to artificial intelligence and the dealing with artificial intelligence, having a clean data to get and process that. Also having this process of continuous data that the data is updated and updated and updated because you do not have a model about something which is now old. You know, you cannot say how can you predict the outcome of a game if the game is over? You have to have the time factor in this part.

Meriyem : OK, and what about the other challenges, according to you?

Ahmed Banafa : We do not have enough people who really can deal with artificial intelligence. We need data scientists and data scientists is not just a programmer. Data scientist is a person who actually knows the number one programming, number two, math, number three, psychology. So this person has to know the psychology. We need to find the pattern in that one so we do not have enough people. That's why they pay them a lot of money here in the United States. They pay them tons of money because we do not have enough of this kind of expertise, that's another challenge you have. The other thing, I have to say, one of the problem we are facing nowadays is the bias. So the AI will look at me because I have some brown skin different than white or black or something. They found out that some of the programs, you know, on Twitter that have a problem with people with a dark skin. They could not recognize them or Adobe Photoshop, it's horrible, you know, that the AI in that system cannot recognize the features of the person who is black. They're biased because of the program. By the end of the day, if I write that program, I will have my own beliefs when I write that program, I will have my own parameters of that program. So this is the ethical side of it. It is how can we take the bias out of the artificial intelligence to make sure that it is neutral. That would be another problem. Here's another problem. I give it to you and you can think about it. You know, I'm talking to you here. And Tesla is about 20 minutes from where I'm talking to you. And Tesla is the leader when it comes to electric car. And they have their own auto pilot, the driverless autonomous car. We have other companies which want to have a completely autonomous car. And we have a problem with that one, which is you look at a car like Tesla, they have all the scenarios, possible scenarios where some people abuse that

system by sleeping in the car while the car is driving by the autopilot, and then they take them from work to home, from home to work because they know they're out. They have a plan. They have a satellite that update the information for them. They make a decision about it. We have many people who died because of this. It was a horrible incident in Florida where this guy was riding his Tesla and it was driving along highway and there was a big truck. Those trucks that deliver the goods from one place to the other just turn around and block the highway, because for some reasons. Now the problem in Tesla was trained on everything except that situation. They never thought that the truck will block that. So the Tesla went under the car. And it's clipped everything even the head of the person. It's gone. So the car continues going until it's arrive at home. And his family came to see this guy without a head and everything is broken. This is a problem about the driverless I mean, we're not ready. There are multiple types of artificial intelligence. We're talking about the general one. We're talking about the super artificial intelligence. We are still at the first level of artificial intelligence. We cannot replace everything about what the human is doing. There's a lot of collaboration and cooperation. We still need the human factor. We're going to get to the level where they will work by themselves at the second level. And then you're going to get to the super, which is artificial super intelligence where they're actually going to control us because they see us as trouble for them. And that's the timeline, it is about another forty-five years if we continue with the speed of developing the artificial intelligence. So that's another problem with it, which is it's not complete. There's so many things still we have to add to the to the model before I can say this is a safe autonomous car, a safe automation inside the factory.

Meriyem : OK, and I have two questions about what you were saying. The first one is can blockchain help to reduce the discrimination done by AI? For example, by increasing the number of data in the machine because there may be more data about the population from the emerging countries, for example, or something like that. How can it help AI with this?

Ahmed Banafa : Well, blockchain can help AI with providing good data. And if the United Nation and the United Nations is actually using the blockchain, there is actually a big project they have in Jordan, which is using the blockchain for the refugees' identity because you know that all the horrible war happened in Syria and a lot of people left Syria and about two million of them are refugees in Jordan and then some went to Turkey, some of them went to Lebanon. And so that's the biggest refugee camp there. You leave your country, you do not have an I.D. with you, right? You just run with your life and you have your kids and you have your family. And they're not going to believe what you're saying. What about if you have kids, people are going to sit there, they're going to have new babies, they're going to get married and all this. How can we have a real ID for the refugees? So they have a project which is features and amity technology. People talking about using their biometrics, the eyes, the fingerprint, and to identify people and give them an ID based on this. So if they came back to ask for help and we already gave them that help, food or water or anything already, you can take it twice, although they decided to leave the camp because they want to go back to their country or go to their friends or

go to Europe or go to anywhere, then they have an ID and their kids will have a certificate that is done by the United Nations. You cannot modify this because it's saved on the blockchain and the countries where they're going to go to, they are partner in that Blockchain, they can verify this. Look at this and say it's the same information. There's no change. So having a nice data, a clean data, a data that we can trust, it's going to reduce that 80 percent we spend on cleaning them. It gives us more time to find a better model when using AI. So that's how they work together.

Meriyem : OK, so if I understand correctly, maybe I'm wrong, but if a machine will be able to use cleaner data, that are more available and the quantity can also increase because in health care, there is a lack of data.

Ahmed Banafa : Correct

Meriyem : How can it increase the number of data, for example, the refugees are giving their data?

Ahmed Banafa : OK, very good, because, you know, the medical and health sector is heavily regulated, right. Because there is a protection for the patient's data. For example, here in the United States, we have something called HEPA, which is a very tough regulation, which is you cannot share the information. You do all this and this and so. But if you can have that blockchain and the hospital understands that this is a safe data, nobody can change it. And the Ministry of Health understand that one. They will feel more comfortable saving their data in the blockchain instead of saying, how can we protect this data? The regulation will be less in this case. Why? Because it is safe. It is encrypted. Now, you're going to have more, you know, pure data and this data will be much available for you. Why? Because I feel safe leaving my data with you. Before you have multiple data, SAP is one of them. You talk about Oracle, one of them, the other companies with a different protection for database. But this is protected and that will be much easier for you to use it. One example I gave to my students two weeks ago is about the case when you go to a doctor. If you change your doctor, you have to go through the same thing and fill the forms, your name and all the information they ask you, have you ever had this and this? What about if I do this information once and I have it saved on blockchain? Then the doctor will be forced to be part of this. And I do not have to fill that form. I only add the new information if I have a new job, if I have something else happening. If we have a new kid, if you have something like that, one I can add. But the information there, like my colour of my eyes, where I was born and all these things will stay the same. It's not going to change. That is where blockchain can save time. And time is helpful for the A.I. because you can increase, as you said, the quantity of the data that's going to be pure. It's going to be quality data. And also you're going to make it faster for AI to go through the data instead of spending all their time to clean it. Now, you can say this is a good data. I do not have to deal with anything other than that

Meriyem : I just have a question for my own comprehension. If I have my AI model, what is the link to access those data. You take it from blockchain and feed it into AI?

Ahmed Banafa : This is a very good question. A.I. is a software, blockchain is a software, and it's using the smart contract again, you can extract this data and have it in tables and those tables can be used by, you know, by AI. There's an interface almost between the two. Because both of them are software so they can talk to each other very easily.

Meriyem : About data management, so the blockchain can facilitate the data accessibility, you already said it, and how can it increase also the transparency and the traceability. For example, if now we say that in 15 years or even now, the AI can do a diagnosis, for example, and you will say to the patient he has a cancer. As a patient, can I trust it? Is there a possibility with blockchain to trace the decision AI has taken? And then as a patient, I can know the reason why. And also the doctor can have the reason why the AI took that decision

Ahmed Banafa : Correct. Exactly like the supply chain, you have the traceability of that one, and if there is a weird answer, they're going to say, "I think this is not right, I can go back and check". How did it get this? How did you get this? You can go back and check the information and it's available right away. It's the software. You can have it on the screen. You do not have to go and look for the records. You do not have to do anything about it. And if this doctor sees it, another doctor can see it as well. Trust is a big factor here, which is whatever you have in that system, you can trust it. Nobody can change it. Now, if the data itself is wrong, we can verify this one. If somebody say the results of the lab is so and so, well, I think this is the problem. Then go on, check it. At least I know where is the issue, because I have this kind of a track of the activities instead of reinventing the wheel and start all over again with the process. I can't just go and look at this one and this one and say, OK, that's the thing. Many times you're going to find somebody who's changing, his doctor will take the x ray and show it to another doctor. The doctor will throw it away. So I want to do my own x ray. But what about if this one is coming through the computer from the blockchain and say he or she did this kind of analysis and x ray, this is the result by Dr. So-and-so in the hospital and the machine used for this one and so on and so on. This is the time. I would feel more comfortable when you tell me about it this is the source of this information.

Meriyem : So you can increase trust?

Ahmed Banafa : Correct. Remember my statement. Internet is about connectivity blockchain is about trust. That's the key thing.

Meriyem : OK, ok, that was my next question. It was how the use of blockchain can increase trust in the decision taken by AI. How would a system work if now I give the power in my patient's hand and he can share his data if he wants or if he doesn't want. And I read about

the tokenization, so the monetization of his data and giving to him, through a smart contract incentive about for example, taking it's on medication or something like that. Do you have maybe a concrete example or an explanation about that?

Ahmed Banafa : Well, it's not about medical because medical your biggest motivation is to be healthy. So you have to share information with the doctor, and if you do not feel comfortable that you're sharing information because you're worried about the health insurance, that's a difference. So a good example of this one is talking about music, for example, or it's like the loyalty card, you know, those card when you are in it, go and buy the same product again and again. Instead of giving a cash, I'm going to give you a token. A token is a cryptocurrency. This token is like money. You can use it in a store with a certain merchant. You're going to see that some of the merchant, they're going to say Visa, MasterCard, Bitcoin, something like this. You could see the name of that token mentioned there. So now I can go and buy using the token that I have gained by listening to this or by sharing my information with Google, by saying every time we share information, we're going to give you five point of our Google token or Google coin, and then you accumulate that one and then you have your own credit. This can be saved in something called digital wallet which is a website. You go there and you find your balance there and then you can take the address of like the QR you have and you can use it to buy stuff. You can go to the store and have it on your phone and say, OK, I want to buy this and this and then they can scan to see if take as much as the cost for that one from that QR. It is similar to the gift card. If you have a gift card, somebody send it to you. You can use it online, you can use it in person.

Meriyem : It can also, like we said, allow to have more data accessible for A.I? So as a consequence, you can also increase the research and development, for example, like they will have more data, they can train also better AI?

Ahmed Banafa : Yeah, correct, that's true.

Meriyem : How is it going to help the emerging countries, what about the implementation there?

Ahmed Banafa : Well, it's going to help them with many things, number one is the example I gave you about the refugees. So having the information that's going to help them with this. So I can go and open a bank account, I can go and buy stuff, and I can do so many activities out of this. And the other thing is, that is making everything digitize. I mean, it depends on the infrastructure they have. So if I want to get my information, I can get it online instead of printing those papers and the paper is going to be lost or modified or counterfeited. So it will help make thing digitized. Many countries, you know, you can talk about countries like the United Arab Emirates, you can talk about other countries where they have something called the digital government. And the records are actually on the blockchain countries like Switzerland. And what they have done, they have the voting

system which is actually on the blockchain so it is going to protect the vote, nobody can change it. Every time you need security and trust, think about blockchain. That's the mentality for any country. They are going to say, OK, you want security, you want trust go for the blockchain. It's not difficult. The government can do it because they have the money. There are companies like IBM, they use their own private blockchain technology called Hyperledger, that's the name of it, most of the companies are using it. Walmart is using that one to trace the food part of the Food Trust Network of IBM. And that is available. And many of the countries that I read about and I deal with them they're using this technology. It's a private blockchain. And so they have control over the number of the computers. That it's not the case with Bitcoin where you do not know how many nodes will have that information.

Meriyem : Yeah, but it can be a problem about the infrastructure in the emerging countries, if they do not have it?

Ahmed Banafa : Yes. I mean, let's be honest about it. You're going to go with blockchain and people cannot find food to eat. Which one is more important. Which one is more urgent. Provide them with food and water, clothes and medicine. Or you want to go with the high technology. This is this kind of project that can be done by the United Nations. It's like the United Nations can go there, provide them with the food, providing this one, but keep records of everything on the blockchain. So to ensure there's no abuse of the funds, there is no corruption that the people and those governments do not abuse by taking the funds. So we'll give it to the people who deserve it. They have their name, they have their ID and they can give it to them right away. So the non-profit organizations will benefit big time from that.

Meriyem : OK, and we talked about discrimination and unfair biases, but do you have something to add.

Ahmed Banafa : So it is a software written by certain people. If they have bias, bias is going to show up in the software. That's why you need somebody to check it. You have to have some rules for ethics. Microsoft, they have the rules of ethics for the artificial intelligence that it should do. Every time you see any kind of bias, you shut it down completely. I'll give you an example. Meriyem, you're going to be surprised about this. It happened in Australia, like two years ago. The Australian government in Sydney, they have a facial recognition system to make it easier for people instead of having their passport. If you're a frequent flyer, they just get in and they look at your face and they're going to say, OK, we know who you are. And, you know, Australia is close to Singapore and Malaysia and it's in Asia, you know, part of the world is the Pacific Asian countries. And the system, when the camera was on, anybody who is of Asian descent, the system, was telling them open your eyes, open your eyes. And that guy, his eyes were open. But this is their features, they're not like us. The system thinks that they are closing their eyes or something like this. So that's created an international crisis because who designed that? You see the problem.

The person who designed this one should take into consideration that the eyes are different for different people and have taken all the scenarios for that one. Never took that in consideration and felt that everybody has the same design as his own race. And they set down the system and some of the passengers, the Asian person, especially from Japan, they sued the government of Australia for this because this is discrimination.

Meriyem : And can blockchain help to provide data from different countries in an easier way to reduce discrimination?

Ahmed Banafa : Because you have the same information without any modification. If I'm in a certain country and they do not like me, they can change my information. But if it's in the blockchain, it's going to stay the same. So protecting identity is very important. Also for keeping the people instead of changing the information. You know, somebody is a fugitive running away. Even if you have a different name, there is other things that will say who you are. That what is identify.

Meriyem : And what about interoperability?

Ahmed Banafa : OK. OK, that's good. It means standardization. That's what it means. We have a problem with the blockchain, of standardization because you can go to Amazon and get your own blockchain, you can go to IBM and have your own blockchain, you can go to Microsoft, but you cannot mix them. So if you go and have IBM as your own provider of the blockchain, you cannot just bring it to, you know, another program from Amazon and interface with that one. They won't allow it. It is not something that you look at it and say it doesn't matter what you use. The example of this Meriyem is I'm talking to you. I have my camera which is Logitech, my monitor, which is from Gateway and my desktop is from Dell and HP. So I have a mix of companies. Why? Because they use the same standards, it's plug and play. That's it. Plug and play. But if we do not have that, then the computer will never accept my monitor, will never accept my keyboard and never accept my camera. It has to be all from one company and this is what we have. No standardization is also another problem and for good reason, because blockchain industry is hundreds of billions of dollars' industry and nobody wants to give it away. Everybody wants to have control and have the whole market for themselves.

Meriyem : And can it prevent from having a big quantity of data? If I want to develop machine learning methods and then I want to take data from IBM, but I need others, which are from another company on another blockchain. Then it can prevent me from collecting a big amount of data? We know that machine learning needs a lot of data to perform.

Ahmed Banafa : Correct. That could be a problem. There is something around it because data is data by the end, data is you can you can modify it by the end of the day. But if we have the same standards across the board, it's easy for me to just export and import from those systems and run it. But now I have to do multiple steps. I'll be OK with IBM. But now

if I take this one from Amazon, I have to do a few steps. So it's going to be compatible with what I'm having. So you adding some difficulties to the process.

Meriyem : So for now, I mean, it can be difficult still to merge like blockchain with A.I. due to interoperability, for example. You can be one of the challenges that we can find to integrate this two, you think?

Ahmed Banafa : Yes, but it's not a big challenge for one reason, blockchain is still small. And the player number one in blockchain is IBM when it comes to the private production. So they almost control the market in this part. It's going to be a future problem when we talk about the different systems talking to each other, that's going to be a problem. And that's why we need to get the IEEE, the organization, the Institute of Electrical Electronic Engineers, the one that brought us the Wi-Fi standards to bring some standards to the blockchain so the data itself, it doesn't matter who is processing the data, the result is the same.

Meriyem : Ok. And I also have a question about how can it help with governance and legal? Now you said about the driverless car, an accident happened with Tesla and now we want to know who is responsible for this. Is the fact that we can trace back all the information or maybe the decision that the system has taken, can it help to say, the producers or Tesla is responsible?

Ahmed Banafa : Yes, Correct, you keep the records of all the steps and you can go back and find. The example you mentioned is good. If you have a store and a robbery happened there and the morning you find the doors are open and some of the goods are not there and the money is stalling, what are you going to do? You're going to go and look back at the TV, the cameras, and trace back what happened last night. And if you have this one stored, then you can find out who did that especially if you have an infrared cameras and this is what I'm talking about. This is the same thing with the blockchain, it keeps recording, recording, recording. And if something happened, they're going to look at this car and this car, they're going to see the trace of this one. They can make a decision about it. And they say this is your fault and this is all not your fault, OK?

Meriyem : And I also have a question about, we know that for now, that the speed of blockchain can be an issue like to process the information. And as you said, machine learning has to be dynamic. Can blockchain provide information, so it will give data that will be fed again into the machine thanks to blockchain as it will be registered or not?

Ahmed Banafa : I have a specific example about that, because it's the relationship between the data. I mean, Blockchain is not real time. It's it is something called almost real time. There are systems that go up to 15000 transactions per second. Blockchain, at this stage, it is not a real time when you can just extract the information right away from a car or from Camera and then process it. It's more like it's a database which stores the data and

then the machine learning will come and take this data and study it and have a model out of this. It's exactly like if you are in a hospital and then by the end of the day, all the data will be stored and it's all available and then AI will go and study this one and see if there is an increase in the cases of this. It can give you this kind of analysis. So real time processing is not there yet, which is right on the spot like Dashboard. You can get this information because of the nature of the blockchain itself.

Meriyem : Okay, but in the future, maybe it will be possible?

Ahmed Banafa : Oh, absolutely. There are some system now reaching 15000 transactions per second.

Meriyem : And now, for example, if I will say that an AI is at its beginning and it will provide a diagnosis, and I have a cancer or whichever disease, and it will provide the information that I got sick. Can the AI take back the data that you gave that is registered on blockchain, then you will say, OK, she has that symptoms and it will take back again the new information and make like as a circular system and then back into the machine again and again.

Ahmed Banafa : OK. OK, well it's a software. You can do that. But once you get things on the software, which is basically a block, you can create another block with the new information. And that will add to the chain another block with this information. But once you have it in the system, it's there, it stays there. It's not something that you can just like a container, take out and put back. No, bring another container, bring another container, bring another container where you can have that information and say, OK, can you check the next block because now we have new information. You can take the results from the first block and put it in this one and say, can you check this for me? It's not difficult because the program itself is very short and the size of the block is very, very short. So it's not a big problem of creating thousands of blocks that have all the information. The key thing about, it is I want to keep it so, just in case I made a mistake in the analysis. So I'm going to say we made a mistake. Let's go and check and see where we missed that part. And this is where the benefit of the record keeping and trust and security is in the blockchain. It's not for processing data. It's for storing data and make sure the data itself is secure and transparent. And it is immutable, nobody can change it.

Meriyem : Yeah. And blockchain is not a database right?

Ahmed Banafa : It is not a database, yes.

Meriyem : So it stores to another place and it's the blockchain which point out to that ledger?

Ahmed Banafa : Yeah, it's not a database. A database has as an admin who controls it and

a database is centralized and database is the main thing about database. And I can send you a diagram after we finish that will explain the difference between the two. Database does four functions, which is create, delete update, read. Those four functions you created, you read it updated and deleted. For blockchain, there is only to read and write. That's it. You cannot update. You cannot delete. So two function is not available in the blockchain that is available in the database. And database is very fast because it is a centralized system.

Meriyem : But can you store data on blockchain?

Ahmed Banafa : Oh that's what happened. Exactly. That's in the store. You can store this data and it's sitting there and nobody can change it. Correct. That one is similar but other functions are different.

Meriyem : OK, and what about the security challenge and the 51%? It can be a threat especially if it happens in health care?

Ahmed Banafa : That's right. That's right. The fifty-one percent attack is one of the problem that faces the blockchain. But it's very difficult to do. I'll give you an example of that. I tell my students that the main goal of the blockchain is not to say that you can never attack. It is so difficult that it's not worth it. If somebody will say that I would like to rob the bank, I go to the bank and steal the money from the bank. That person in the morning went to the bank with his gun and then he looked at the bank and there are police cars around the bank and there are snipers at the top of the building. And he is going to say, well, I can still go, but I'm going to lose my life in this case. So it makes it so difficult for people to do that. In order for you to reach the 51 percent attack, you have to have so much computing power. You have to have so much time that the money you're going to spend on this is more than the benefit from stealing those data. So that's number one. Number two is, there are safeguards. For example, there are some of the systems that I'm talking about, the private blockchain in this case, if they see that somebody changed the information, they shut down the whole system, they just shut down the whole system. They just stop everything before they can get the fifty-one percent were to convince everybody to change the information.

Meriyem : Do you think about other issues regarding the integration of these two?

Ahmed Banafa : Well, just finding the right people. That's another problem you have to think about. How can I find the right people? The skill is expensive. Blockchain is expensive. It's not cheap. That's why you have to make a decision. What kind of data you're going to put there. That's why only big companies, governments and organizations, international organizations, they can offer that one but small companies, they do not need it. And I'll send you another diagram about why do you need it. It's a PowerPoint. I'm going to send it to you. That will explain some of the information I teach to all.

Meriyem : I was reading that, for example, today, that creating a new model, a machine learning model is not the challenge today because we can do it. But what is difficult, is to access the data because either we do not have enough data or either the big companies will own it and we have to make a deal with them and pay them to get them. But they were saying that blockchain can help to provide data due to little companies and make that the big companies are not the only one making AI.

Ahmed Banafa : Correct. Correct. This company Singularity deals with this kind of problem, which is making it fair for everybody. You do not have to just only rely on big companies. Now to deal with big companies about how to get the data, we need regulation and this regulation would force them to give us the data. Otherwise, they're not going to give us those data. This is again, the regulation is another challenge you can face here, because you can have the best AI, you can have the best machine learning, but data is like a car without a gas.

Meriyem : OK, I think that for this part, that's it, do you think about something else?

Ahmed Banafa : I think we covered a lot of territory, so I feel comfortable about that.

Meriyem : OK then. Maybe about the technological acceptance model. It's about to see if you think that in the future it will be adopted and what is a probability, etc. So we talk here about the perceived usefulness of the system, the perceived ease of use, the attitude toward the system, the behavioural intention to use it and the actual system used. So would the integration of the system can enhance the AI and users' performance? And does it seem useful according to you?

Ahmed Banafa : Yes. I mean, and you see the article I gave you, I give a certain step about how to do so.

Meriyem : And would it be easy to use and to implement?

Ahmed Banafa : Over time, yes, because we're going to improve the user experience and user interface, it's going to be much easier for us in the future.

Meriyem : OK. And do you think that blockchain use in A.I. is understandable and clear?

Ahmed Banafa : It's still evolving. It's not clear because both technologies are really technologies that not everybody understands. So AI I will be fine. People understand that. They see application of that one with Siri and, you know, with Aleksa and all the system. But the blockchain is the issue. Not many people understand. What is the blockchain. The only thing they know about the blockchain is bitcoin. You do not see the application until you use it.

Meriyem : OK, so it makes a reference to my next question, which is, do you think that improving blockchain literacy to people will take time before being able to use it for AI?

Ahmed Banafa : That's correct. There should be some education, especially for the decision makers. You know, I give speeches to the companies for free just to tell them about the blockchain technology. And after I finish the talk, they really appreciate. We never thought it can do this until they know about it, for them, it is cryptocurrency. It is Bitcoin.

Meriyem : Yeah. for sure. OK, in the future, do you think that the benefits will outweigh the costs.

Ahmed Banafa : Correct. I mean the more we have companies that deal with those, the more the price is going to go down. More people will be working on the blockchain so the availability of skilled people will be higher.

Meriyem : Your impression about the implementation of these two together?

Ahmed Banafa : It's a perfect match, it's a matter of time for the blockchain and AI to work together. One of them is the muscle and one of them is the brain. That's basically why I look at it.

Meriyem : So you will go for it, you?

Ahmed Banafa : Oh, absolutely. Yes, 100 percent.

Meriyem : And so the last question was, if in the future you think that these two have a big potential together, in the long term or in the short term, what do you think?

Ahmed Banafa : It's within five years that we're going to see some applications. In 5 years you are going to see application because people are really good at that. And then after that, in 10 years, it's going to be the norm. An added part of the blockchain will be the AI engine itself, like the smart contract AI engine. The blockchain will be there.

Meriyem : And I have one question that pops up into my head right now is that I read in a lot of articles that one of the ways that blockchain and AI can interact together is to take joint decision. It was absolutely not clear in my head. Could you maybe elaborate on this?

Ahmed Banafa : Well, the decision making is based on a model or insights to get from the AI. And that insight will be compared to some information you have with the blockchain. And if they have it, they compared it and it is correct, then you can go ahead with that decision, because this is how you can talk about they joined together in that decision. The blockchain is a platform. You can say whatever you want there, whatever information you

want there. So if AI says this person is racist, the colour is this, the food is this and then there is information about that person in the blockchain is the same then that's going to confirm it. If not, they're going to say go back and check with AI what they say. You're missing something in this case. So you can use it as some way for you to check on the results of AI. But then if we say like for example, two machines are using the same blockchain information, it won't help the joint decision between the machine or it will if you were talking about two machines with machine learning having a result, they're going to take the information from the same blockchain. So the results would be the same unless the models are different. What I'm talking about is the confirmation. You go to look at the result and then you compare it to whatever you have in the blockchain, confirm that this is correct. This is really for example, I give you an example of this you know, the Australian airport, when they scan the faces of people to get them in. So scanning the facial recognition, this is part of the AI. We understand that. Right. You know, you're talking about the feature of that person. If this data is stored somewhere on the blockchain and we compare them and they are the same, then I agree with you that this person is who he is, then we can let this person come into the country. So this is where you confirmed the decision by the AI by having the result already there on the blockchain.

Meriyem : OK, ok, OK, perfect. And I think that is it. Thank you very much for your time.

Ahmed Banafa : With pleasure, do not hesitate to contact me if you have other questions or to set up another call.

Meriyem : Oh thank you very much. Have a nice day.

Ahmed Banafa : You too, bye.

Interview Philippe Coucke

Meriyem : Bonjour Monsieur

Philippe Coucke : Bonjour Meriyem, comment vas-tu ?

Meriyem : Très bien et vous ?

Philippe Coucke : Egalement, merci

Meriyem : Tout d'abord, avant de commencer, puis-je enregistrer cette conversation et l'utiliser à des fins académiques ?

Philippe Coucke : Oui, pas de problème.

Meriyem : Super ! Merci beaucoup. Pour me présenter en quelques lignes, je suis étudiante en 2^e année de master en ingénieur de gestion à Louvain-La-Neuve en Belgique. Je termine mon année avec un mémoire sur la blockchain et l'AI. Ma question concerne le fait de voir comment est-ce-que la blockchain peut aider l'AI à devenir plus trustworthy, qu'elle soit plus sécurisée et adaptée par la population. Je vous expliquerai plus cela en détails par après. Cependant, pour us précise, ma question est la suivante : *"Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence?"*. Pourriez-vous également vous présenter ?

Philippe Coucke : Je suis chef du service de radiothérapie au centre hospitalier universitaire à Liège. Je m'intéresse depuis 3-4 ans sur l'évolution de la médecine à travers l'avènement des nouvelles technologies .

Meriyem : D'accord, merci beaucoup. Et quel est votre lien avec la blockchain et l'intelligence artificielle ?

Philippe Coucke : Mon lien essentiellement avec le développement des nouvelles technologies est que je m'y intéresse fortement contrairement à beaucoup de mes collègues dans le secteur médical. Et que je me rends bien compte qu'on est à l'avènement d'une nouvelle aire. Je n'ai pas de lien direct avec l'AI car le monde hospitalier n'est pas encore prêt.

Meriyem : Oui, c'est ça. D'ailleurs, j'ai eu une interview avec votre collègue, le docteur Kohl. Il m'avait dit justement qu'il n'était pas assez au courant, mais que vous étiez justement apte à répondre à mes questions. Et comment définiriez-vous rapidement, en quelques mots, la blockchain ?

Philippe Coucke : Le terme est excessivement plus simple à expliquer si on utilise en fait une terminologie anglaise distributed ledger technology, manière en effet de distribuer et d'échanger des informations, des données entre des utilisateurs de confiance.

Meriyem : Parfait et selon vous, quels sont les problèmes majeurs que rencontrent la blockchain aujourd'hui ?

Philippe Coucke : En principe, ça devrait améliorer les échanges de données, augmenter la sécurité. La problématique, je ne peux pas vous répondre d'un point de vue technique. La seule chose que je peux vous répondre aujourd'hui, c'est une problématique plutôt culturelle. Je pense au niveau de l'adoption de telles technologies dans le monde médical qui est excessivement conservateur. Nous avons l'habitude de rester assis sur des silos de données qui nous sont propriétaires entre guillemets. Et on a un mal fou à échanger. Le deuxième, c'est l'interopérabilité également des systèmes. Il faut savoir que pour pouvoir échanger des données, il faut y avoir accès. La problématique, c'est que à nouveau, beaucoup de logiciels que nous utilisons dans le monde des soins sont à nouveau sous un format propriétaire et n'échangent pas les données avec d'autres systèmes.

Meriyem : Et là, vous pensez qu'à ce niveau-là, la blockchain pourrait justement du coup être une solution ?

Philippe Coucke : C'est plus une problématique de culture industrielle. Reprenons bêtement l'exemple. Pendant la crise du coronavirus, on a utilisé des ventilateurs, d'accord. Ces ventilateurs contiennent bien entendu des informations essentielles si on veut gérer la manière dont on ventile les patients, par exemple. Si on veut faire une méta analyse de ces paramètres-là, le problème, c'est que l'accessibilité des données est bloquée parce qu'il s'agit à nouveau d'un format propriétaire. La blockchain en tant que tel ne résout pas le problème. Ce qu'il faut faire c'est changer la culture des gens. Admettre que nous vivons de plus en plus dans un monde où les données doivent être accessibles.

Meriyem : Là, on a parlé un peu des avantages de la blockchain. Au niveau des désavantages, je suppose qu'au niveau technologique, ce n'est pas une question à laquelle vous sauriez répondre ?

Philippe Coucke : Ce n'est pas trop mon souci entre guillemet, je ne suis pas un expert en matière de blockchain. Donc je ne pourrais pas donner une réponse valable. Je m'intéresse beaucoup plus à l'utilisation de l'intelligence artificielle. Mais j'admets, si vous avez lu mon livre, j'admets que dans l'écosystème que je prône qui est basé sur du big data, de l'intelligence artificielle, il faut mettre en place un système qui permette un échange sécurisé des données et que là, la blockchain apporte des solutions.

Meriyem : Oui, justement, c'est exactement à cette partie-là que je me suis référée avant de vous contacter et je me suis dit que vous pourriez potentiellement répondre à mes questions, alors je ne vais pas m'attarder trop sur la partie blockchain. Donc, au niveau de l'intelligence artificielle j'aimerais aborder les problèmes auxquels celle-ci fait face et ceux, évidemment, dans le domaine de la santé. Et après, on pourrait partir justement sur les questions concernant l'intégration de la blockchain avec l'intelligence artificielle et voir ce que vous pensez justement de ce modèle. Un peu en lien avec la partie du livre auquel vous avez fait référence. Donc voilà. Est-ce que vous pouvez m'expliquer rapidement, selon vous, quels sont les problèmes que l'intelligence artificielle fait face aujourd'hui ? Vous avez déjà expliqué l'aspect de la culture. Mais est ce qu'il y en a d'autres auxquels vous pensez ? Au niveau éthique, par exemple ?

Philippe Coucke : Alors il y en a beaucoup. Il y a ce sentiment de la plupart des soignants qui sont en fait en face d'une boîte noire dont ils ne connaissent pas le fonctionnement. Ils ont du mal à faire confiance aux conclusions qui en sortent. Il y a également la problématique

des données. On revient sur la problématique de base, la valeur des données, la qualité des données. Parce que garbage in, garbage out. Et aujourd'hui ça pose énormément de problèmes au niveau médical, car il n'y a pas de standardisation de la manière dont on enregistre les données dans les dossiers médicaux. Donc pas de formatage, très peu de données qualitatives, très peu de menus déroulants, très peu de questions et de réponses booléenne, oui non. Si on ne résout pas ce problème-là, le big data reste un leurre. On a parlé également de l'interopérabilité, qui est encore un autre problème. Puisque on couve jalousement nos données, on n'est pas prêt à partager avec d'autres. Tandis que dans un écosystème de big data, il faut un maximum de données provenant de différentes sources. C'est déjà bien non ?

Meriyem : C'est parfait. Peut-être que je peux vous dire aussi les autres que moi j'ai trouvé pendant ma recherche de littérature. Par exemple, la discrimination et les biais.

Philippe Coucke : Oui, exact. Exemple typique en dermatologie. Les logiciels automatiques d'intelligence artificielle capables de reconnaître des problèmes dans la race caucasienne, mais totalement incapable de le faire pour la race africaine. C'est l'exemple typique du biais. Quelque part, l'analyse automatique de l'image arrive à le faire pour l'un, pas pour l'autre. Autre biais, on le retrouve déjà dans les essais cliniques classiques. La plupart des essais cliniques sont, entre guillemets, infestés de race caucasienne. On s'aperçoit par exemple dans les essais qui sont menés dans le contexte du coronavirus. Là aussi, il y avait une majorité de blancs dans les essais. Donc à ce moment-là, on biaise directement la capacité, la variabilité des données est biaisée.

Meriyem : D'accord. Et par rapport à la privacy et cyber sécurité?

Philippe Coucke : Moi, je pars du principe et je crois que je l'explique dans mon livre également, data philanthropy, la philanthropy des données et donc en fait, les gens se gargarisent avec privacy, mais nous sommes dans un monde où je pense et c'est malheureux de le dire, mais c'est un constat mais le privacy n'existe plus maintenant en moins de 3-4 clics, si vous êtes sur les réseaux, on arrive à vous identifier. On sait exactement qui vous êtes. Donc, honnêtement, privacy est un leurre. J'appelle à la philanthropie des données. Je suis un citoyen, en tant que citoyen, j'ai des droits, j'ai des devoirs, je mets mes données à disposition pour qu'ils puissent servir au plus grand nombre. Dans un contexte de big data. Mais je suis aussi conscient que je ne veux pas que mon dossier médical figure sur la première page de la Meuse. Qu'ils soient accessibles dans un contexte d'analyse de big data. Mais il faut bien entendu mettre en place des garde fous et ces derniers peuvent être mis en place par une technologie de type blockchain où on contrôle qui amène l'information et qui l'utilise.

Meriyem : OK, donc ce serait une potentielle solution, pour vous la blockchain ici ?

Philippe Coucke : Oui, la sécurisation.

Meriyem : OK, et au niveau de la cyber sécurité ?

Philippe Coucke : Oui, je ne suis pas hacker, mais il faut imaginer qu'ils sont suffisamment inventifs pour hacker d'une certaine manière. Il n'y a pas de système qui va être totalement étanche à quelques tentatives d'hacking que ce soit. Je pense que c'est un

leur et je pense aussi que les gens ne sont pas conscients que les moyens à disposition technologiques de la part des cybercriminels et en règle générale, largement supérieure à celle mise en place pour protéger le système. Sans parler de l'avènement de la superpuissance informatique, des moments où on va basculer sur l'organisation de hackers qui ont des puissances beaucoup plus importantes que les autres, on est mort.

Meriyem : Oui, c'est un problème. C'est vrai même, mais ça peut déjà aider un petit peu avec les systèmes actuels qui sont peut-être moins sécurisés ?

Philippe Coucke : Oui, je pense que la crise que nous avons connue a mis en exergue ces problématiques par la multiplication des portes d'entrée possibles au système. Les systèmes connectés relativement mal protégés, les ordinateurs à distance relativement mal protégés, c'est multiplier le nombre d'accès et portes d'accès.

Meriyem : Alors j'ai vu aussi la gouvernance et legal aspect.

Philippe Coucke : Là, je pense en effet qu'on est en face d'un réel casse-tête chinois. Certainement quand il s'agit en effet d'un algorithme d'intelligence artificielle. J'ai participé un jour à une conférence très, très intéressante qui était menée par des juristes en matière de qui est responsable de quoi. Il est clair que si vous avez une intelligence artificielle dont l'algorithmique est continuellement en train d'évoluer, se pose bien entendu la question à qui revient finalement la responsabilité à un moment donné. Il est clair que si vous avez un algorithme d'apprentissage non supervisé, plus personne n'est responsable parce que vous ne comprenez pas l'évolution de l'algorithme et donc on ne peut pas reprocher à un humain que la situation dérape. Là se pose éminemment un problème éthique et juridique.

Meriyem : Très intéressant. Vu que la blockchain permet à chaque fois d'ajouter un bloc d'information qui a eu lieu et qui est maintenant protégé et sécurisé, pensez-vous que si maintenant la blockchain offre la possibilité de tracer la décision et les steps qui ont été prises justement au sein d'un algorithme afin d'arriver à une décision possible, est-ce que vous pensez que ça peut aider à expliquer d'où vient l'erreur et comment ?

Philippe Coucke : Ça permet une traçabilité. Mais le problème c'est est-ce qu'on peut permettre un apprentissage en continu non supervisé ? Ça je n'en sais rien et ça me semble difficile parce que là vous arrivez à un certain step et vous le bloquez. Pour continuer à alimenter un algorithme de nouvelles données, il va continuer à évoluer. Et est-ce que votre blockchain par la suite est assez dynamique pour suivre le mouvement.

Meriyem : Oui c'est un des problèmes de la blockchain. C'est vrai que c'est la rapidité à traiter l'information. Peut-être alors à ce moment-là que remettre les datas au sein de l'intelligence artificielle ou créer une boucle entre guillemets pour que ce soit dynamique, c'est peut-être un peu difficile, mais s'ils arrivent à régler le problème de la vitesse et que justement, les datas peuvent revenir dans la machine, ça pourrait aider.

Philippe Coucke : Il faut que ça reste très dynamique. On sait très bien que la transformation des données vers des informations utiles dépend fortement de la quantité des données qui vont affluer et ça peut aller très, très vite. Les modifications des

algorithmes entre guillemets, un algorithme peut muter trois fois par seconde en fonction des données qui rentrent. Comment assurer, en effet, que vous ne figez pas le système ?

Meriyem : C'est une question qui doit être répondue avec la blockchain. Donc, si ce problème arrive à être résolu, alors vous pensez que ça peut être potentiellement une solution ?

Philippe Coucke : Oui, car vous apportez une solution à qui partage et qui a accès.

Meriyem : Et alors aussi également, est ce que vous pensez que cette traçabilité peut également aider au développement de l'AI ?

Philippe Coucke : Je fais partie des cliniciens qui pensent que moyennant des données qui sont fiables, et qui rentrent dans le système, l'IA aura toujours raison.

Meriyem : Donc, on revient aux datas, à la qualité du data à ce moment-là. J'ai découvert également, c'est que la confiance en une machine, comme vous avez dit au début de l'interview par les patients ou par les médecins ou autres, c'est vraiment un problème pour le développement de l'IA à grande échelle. Et est-ce que vous pensez justement alors le fait que les datas qui soit mis dans une machine, qui ont une plus grande qualité et qu'on s'assure qu'il soit sécurisé, ça peut augmenter la confiance de l'intelligence artificiel et permettre son développement à grande échelle.

Philippe Coucke : Je ne sais pas très bien ce qu'il faudra pour qu'on bascule réellement vers un modèle tel que celui-là, je pense que c'est ce qui va nous pousser, c'est simplement, moi, j'ai toujours clamé que ce qui va nous pousser vers un écosystème différent, c'est que nous n'arrivons plus à financer le système de soins tel que nous pratiquons aujourd'hui, ce sont des incitatifs financiers qui vont être le moteur de la démarche. Le monde médical, une grande partie du monde médical voit ça d'un œil plus que méfiant. Non pas parce qu'il pense que les conclusions sont fausses, mais tout simplement parce qu'ils pensent que leur travail a été remis en question et qu'il ne faut pas se leurrer, si vous avez de l'intelligence artificielle qui est capable en quelques secondes de lire des scanners thoraciques beaucoup plus rapidement et de façon nettement plus efficace qu'un radiologue, se pose la question faut-il encore payer les radiologues aussi chers ? Et donc beaucoup de spécialistes en différentes disciplines médicales sont passés frileux. Parce qu'ils se rendent compte, ils ne sont quand même pas idiots, ils se rendent quand même compte que, in fine, c'est éventuellement leur propre revenu qui risque d'être remis en question.

Meriyem : Donc là, vous pensez plus que ça a un aspect social.

Philippe Coucke : Oui. Mais l'intelligence artificielle ne remplacera pas le médecin, mais le médecin qui n'utilisera pas l'intelligence artificielle va disparaître.

Meriyem : La qualité et l'intégrité des data on en a parlé à quel point c'était important.

Philippe Coucke : pour moi que la condition sine qua none mais aujourd'hui, elle n'est pas remplie. Et donc basculer vers un écosystème baser sur du big data et l'IA, n'est pas envisageable si vous n'avez pas ce prérequis fondamental.

Meriyem : À l'heure actuelle, il n'y a pas vraiment de processus en place permettant justement de s'assurer de la qualité de ces data qui sont intégrés au sein de l'IA?

Philippe Coucke : On peut distinguer deux choses différentes. D'une part, on fait ce qui est L'IA en application d'analyse d'image et là, c'est plus facile à développer. C'est d'ailleurs dans ces domaines là qu'on voit les percées les plus marquées de l'intelligence artificielle, en radiologie, ophtalmologie, en dermatologie. Parce que là, on a des paramètres qui sont objectifs et quantifiés. Et donc, là, c'est facile à faire. Cependant, l'entrée des applications d'intelligence artificielle qui vont rechercher des données tant des dossiers médicaux informatisés, le dossier médical personnalisé. Ça, c'est une tout autre affaire. Parce que là, malheureusement, il y a des papiers intéressants qui sont sortis là-dessus. On sait par exemple que si on soumet notre dossier médical au patient, dans la majorité des dossiers, il y a des erreurs graves. Le patient relève la présence d'erreurs graves dans son dossier, de fausses informations.

Meriyem : Et ça s'est dû à quoi ?

Philippe Coucke : Tout simplement parce que ce n'est jamais contrôlé. Dès le moment le moment où vous rentrez une information, il n'y a pas de contrôle derrière. Quand on sait qu'une grande partie de ces informations peuvent ultimement produire des décisions thérapeutiques qui sont graves de conséquences. Nos dossiers médicaux personnalisés, on parle de dossier médical perdu.

Meriyem : Et j'avais aussi lu que si imaginons, on veut utiliser les datas des patients pour faire de la recherche et que ces derniers veulent rester privés comme vous avez dit, publient des big data et donc partager vos données tout en gardant vos droits de privacy. A partir de cela, on aimerait créer des algorithmes avec plus de data qui viennent directement d'un patient sans passer par les institutions comme les grosses entreprises ou les grosses institutions qui possèdent toutes les données de tout le monde. Est-ce que vous pensez que en supprimant les intermédiaires, les grosses entreprises, ça pourrait aider à aller justement dans ces dossiers médicaux, de transformer les data, parce qu'il faut un certain type de data, et ensuite, les utiliser pour créer des intelligences artificielles plus puissantes, plus rapides et basées sur les données plus pertinentes ?

Philippe Coucke : Je pense que c'est un peu le modèle des pays scandinaves. Ou les gens acceptent de mettre leur donnée à disposition. Elles sont mises à disposition moyennant une sécurisation du système. Pour pouvoir faire ça, il faut avoir confiance en nos gouvernants. Est-ce qu'aujourd'hui on peut avoir confiance en nos gouvernants ?

Meriyem : C'est une grande question.

Philippe Coucke : Aujourd'hui, Les belges nous disent non. Il suffit de voir comment la situation évolue aujourd'hui. Ils disent non, on ne peut pas faire confiance et dans certains pays scandinaves, on fait confiance. La question ne se pose pas. Quand vous êtes né sur le territoire, vous avez d'office accepté, sauf contre ordre de votre part, le fait que vous partagez vos données. C'est le principe du opting out. À un certain moment, le citoyen peut décider qu'il sort du système. Mais en principe, il fait partie du système jusqu'à preuve du contraire. C'est totalement différent chez nous.

Meriyem : Et si maintenant vous pensez que on propose, parce que la blockchain d'aujourd'hui n'est pas du tout quelque chose qui est commun, quand on lit dans la littérature, c'est quelque chose qui va arriver dans les 10, 15 ou 20 ans, selon les études, ça dépend. Si maintenant on donne la possibilité à l'individu d'avoir le contrôle de ses propres données, donc justement via une blockchain, alors que c'est lui-même qui décide ou pas de partager ses données.

Philippe Coucke : C'est un peu le principe de certains pays scandinaves. Ici, on se focalise uniquement sur le dossier médical, mais je fais partie aussi de ceux qui pensent que quand on veut accéder au dossier, il faut avoir toutes les données, pas simplement les données qui sont issues du dossier médical. Il faut aussi avoir accès aux données qui semblent être iconoclaste au départ mais des données qui proviennent de facteurs socio-économiques, des facteurs environnementaux dans lesquelles les gens vivent. Donc qu'il faut aller beaucoup plus loin dans la démarche et avoir accès à beaucoup de données de différentes sources les plus variées possibles.

Meriyem : A propos de l'intégration de la blockchain et l'AI, j'utilise au sein de mon mémoire un modèle qui s'appelle Le TAM model, technologie acceptance model. Et ici, je vais essayer de l'appliquer à l'intégration de la blockchain, et de l'AI ensemble. Pensez-vous que l'intégration de ces deux systèmes, de la blockchain pour l'IA permettrait d'augmenter la performance par exemple, votre performance en tant que médecin, avec tout ce dont on a parlé ?

Philippe Coucke : La réponse est indéniablement oui. C'est indispensable. Comment peut-on gérer aujourd'hui la santé publique sans avoir accès aux données ? Aujourd'hui, nous n'avons pas les données. Nous gérons la santé publique sans avoir accès aux données.

Meriyem : D'accord, le fait de mettre la blockchain comme vous avez parlé dans votre livre, ça permet de sécuriser, comme vous en parlez dans votre livre et on a plus de données pour entraîner l'AI?

Philippe Coucke : Exactement, oui.

Meriyem : Est-ce que ça va être facile, selon vous d'implémenter et de mettre les deux ensembles ?

Philippe Coucke : Ça va être relativement difficile à mettre en place parce que, ce n'est pas une question de technique, la technique suivra, c'est une question de culture, organisation et culture, politique et culture des utilisateurs et changer une culture c'est toujours plus compliqué. Surtout dans le système de la santé qui est fort derrière en termes d'adoption. 30 à 40 ans.

Meriyem : Ah oui j'avais mis 15 ans derrière

Philippe Coucke : C'est gentil ça. Le problème ne sera pas technique, il sera culturel.

Meriyem : Vous pensez que c'est peut-être dû au fait que ça touche la santé humaine ?

Philippe Coucke : Je pense que ça passe par l'éducation des futures générations des soignants. Ils n'entendent pas parler de ces technologies pendant tout leur curriculum.

Meriyem : Tout passe par l'éducation.

Philippe Coucke : Oui, éducation, sensibilisation, explication.

Meriyem : Est-ce que vous pensez que l'utilisation de la blockchain pour l'intelligence artificielle est assez compréhensible et claire ou qu'il va falloir encore du temps avant que cette technologie soit utilisée ensemble ?

Philippe Coucke : Moi j'en vois l'utilité mais je peux vous dire que la plupart des gens dans le monde des soignants d'un, ne savent pas ce qu'est une IA et deux savent encore moins ce qu'est la blockchain. Il va falloir faire de l'éducation.

Meriyem : Est-ce que vous pensez vous qu'introduire cela va coûter en argent et en énergie, mais est ce que juste selon vous, vous pensez que les avantages vont surpasser justement ces coûts ?

Philippe Coucke : Il est clair que changé d'écosystème ce n'est jamais gratuit. Il va falloir investir largement pour pouvoir basculer d'un système à l'autre. Mais à terme, on sait très bien qu'à terme, on va être gagnant puisque les décisions seront nettement mieux orientées parce que basées sur des données validées, objectives, quantifiables et qualitatives. Par conséquent, on fera des économies. Vous avez lu le livre, les 4 indicateurs clés de la santé publique sont effroyables. Aujourd'hui, 50 pourcents des actes sont inutiles, 42% le taux d'inefficiences 10%, le risque de mourir ou de ressortir dans l'hôpital moins bien que la façon dont on y est rentré. Un diagnostic sur 20 complètement erroné. C'est ça la réalité du terrain. Donc, on ne peut faire que mieux, on ne peut faire que mieux, mais ça coûte, ça coûte. Et le problème du coût, c'est qu'aujourd'hui, le secteur de la santé investit beaucoup trop peu dans ces technologies-là. Il faut revoir son rapport à l'investissement.

Il n'y a aucun secteur d'activité humaine qui peut se permettre d'investir aussi peu en matière de nouvelles technologies d'informatique et de blockchain, et d'intelligence artificielle IA. Aucun secteur d'activité humaine, qui peut se permettre ça, ils disparaissent s'ils font ça ! Sauf le secteur de la santé.

Meriyem : Et alors quel est votre feeling, votre impression par rapport à l'implémentation de ces deux ensembles ? Parce que je vois que vous avez dit dans votre livre, par exemple, que cloud based solution pourrait être une potentielle solution. Mais après, vous dites directement que vu qu'il faut de la sécurité et de la privacy, si mes souvenirs sont bons, que la blockchain pourrait justement être une solution. Quelle est votre impression par rapport à l'implémentation de ces deux technologies ?

Philippe Coucke : Pour parler de mon impression, ou de l'impression du monde des soignants ? La mienne, vous la connaissez, vous avez lu le bouquin, pour moi c'est incontournable, on doit embrasser cette technologie-là, il n'y a pas d'autre choix. Aujourd'hui, on sait très bien que nos systèmes médicaux ne sont pas sécurisés du tout. Rien de plus facile que d'hacker un hôpital. Nous ne partageons pas nos données de façon sécurisée. Nous n'avons pas de traçabilité de ceux qui ont accès à des données. Promenez-

vous dans un hôpital, vous pouvez introduire un cheval de Troie ou un virus quand vous voulez et où vous voulez, comme vous voulez. On est dans un système complètement dépassé. Le problème c'est que la plupart des gens n'ont pas encore réalisé ça.

Meriyem : OK, donc, vous avez un signe positif et que les deux ensembles pourraient vraiment, au final, se complémentariser ?

Philippe Coucke : Oui, je pense

Meriyem : Ma question, est-ce que vous opteriez pour un système pareil

Philippe Coucke : Je crois que je sauterais dessus.

Meriyem : Donc, vous pensez que dans le futur, ils ont un potentiel vraiment énorme ensemble ?

Philippe Coucke : Ah oui je pense et d'ailleurs, toute la crise du Corona est une preuve du fait que nous devons aller dans cette direction le plus vite possible.

Meriyem : Et dernière question, par rapport à l'implémentation de ces technologies dans les pays en voie de développement, qu'en pensez-vous ?

Philippe Coucke : Je peux vous dire que dans certains pays, on m'a invité à un groupe de travail de la Commission européenne en la matière et j'ai eu le plaisir de rencontrer des gens qui ont travaillé dans des missions de ce type là au Kenya par exemple. Et je pense justement que l'implémentation de telles techniques soit probablement plus simple là-bas qu'ici. Pourquoi ? Parce qu'il n'y a pas d'existence et que finalement, vous répondez à un problème de santé publique majeur et qu'il n'y a pas de structure, donc pas de batailles de clocher ni de bataille d'arrière-garde pour sauvegarder des avantages. Clairement je pense que dans les pays du tiers monde, ce type de solution sera plus rapide que dans votre vieille Europe.

Meriyem : Vous ne pensez pas qu'il y a un manque de technologie au niveau des habitants ? Ils ont aussi la technologie mais à moins grande échelle. Est-ce que vous ne pensez pas que ça peut être un problème ?

Philippe Coucke : Ce problème peut être aisément résolu. Je faisais des conférences au tout début sur l'avenir de la médecine, je faisais le parallèle avec l'avenir sociétal. Il faut savoir qu'on peut produire un smartphone pour un dollar. Dès le moment où vous êtes capables de faire ça, c'est quasiment accessible à tout le monde. Et ses pays là en voit clairement l'intérêt parce que justement ils n'ont aucune infrastructure et que c'est beaucoup plus simple de mettre quelque chose neuf en place que d'aller décortiquer ce qui existe et ça ira probablement beaucoup plus vite dans ces pays-là. Un autre point important est que ces pays-là n'ont pas affaire à des réglementations extrêmement sévères qui limitent tout cet échange de données et de technologie. Ce qui peut être un frein ici.

Meriyem : D'accord. Merci beaucoup mais voilà, je ne vais pas vous tenir plus longtemps. Vous avez dit 45min, il est l'heure. Un grand merci

Mr Philippe Coucke : Avec plaisir

Meriyem : Bonne journée à vous

Mr Philippe Coucke : A vous aussi, au revoir

Interview Julian Fifield

Meriyem : Hi Julian Fifield, how are you?

Julian Fifield : Good, thank you very much. You're from Belgium, right?

Meriyem : Yes, from Belgium. Thank you for joining the call. I will present myself quickly. My name is Meriyem and I am a second-year master student in Business Engineering, in Belgium. And I am finishing my master with a thesis about how blockchain can impact AI. *"Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence?"*. Could you introduce yourself, your link with blockchain and AI as well as with healthcare?

Julian Fifield : Yes, so I am focusing on blockchain as a transformative technology for some years. I am particularly interested in its immutability, its tamperproof nature of data. And then, given its tamperproof nature, what can we do with it, what are the area of interests where we can leverage it. I have a perspective on this which has to do with traditional IT and traditional systems and in traditional data. The problem is the data is often dirty, wrong, counterfeit or it's got human errors, or different issues you can get with data. Which means, if you try to run analytics or try to understand the data, you always come against the uncertainty about the data that you've got access to. Which means you can't do sophisticated things with it. AI is fantastic but unless it gets good data. You cannot do something good with it otherwise. And the biggest problem with AI is that AI people will tell you they can't get decent data and if you can't have decent data, it's almost not worth the bother.

Blockchain's primary ability and potentially if it is done right, is to capture accurate information and then effectively digitize it in a non-tamper proof way, which means if you got some accurate, truthful data, which cannot be tampered with, you can then start to run interesting artificial intelligence on top of it. So that could be all sorts of things, the digital identity, you, the person who is in the system, see if the person is the right person. You've got the right person and therefore you can trust the data about it. Therefore, you're not talking to a dog. People identity and identification or authenticity is key. You can do it without blockchain, but it's a lot of work, but blockchain is one of the few, if not the only potential mechanism for capturing truthful information. Conveying it across the supply chain or the value chain and then being able to perform interesting things with it, like artificial intelligence and machine learning on top of it. So that's its key power. And that's the key thing. Artificial intelligence is pretty much a waste of time, unless you've got powerful, accurate data. And everybody will tell you this, I'm working on a project now. We have got a problem with trying to take pictures, facial recognition of animals. I won't bother you with the details of what the project is, but to accurately collect information about an animal or indeed a human, you must collect information, not just the image. So, for example, here is a picture of a cow. What sex is the cow? What breed is the cow? How old is the cow? What you're trying to do is to identify the key features of the animal. You can then start to say with a high degree of certainty that if the machine receives another image of a cow, the machine can check on the basis of what the system has learned. This kind of cow, this kind of breed, this kind of age. You can then start to do some interesting things. You got this nice starting point with the data and you put in a lot of effort into collecting good data. With blockchain, truth is super important. Information can't be

changed, updated, deleted. That's what goes on in normal business practice as in normal business practice, you collect data, it turns out to be the wrong data. You go into the database and update it with the right data. People do that all the time. Most organizations with databases, large and small, spend a huge amount of time just keeping the database up to date. And of course, fail often because it's almost impossible to keep the data off the boat. The problem now is that it's a tsunami, there's so much data out there. This is almost impossible and it's getting worse and worse and worse. We need tools, techniques and new approaches. And blockchain is potentially a good way because what you're doing is you're going through all of the parameters of the accurate data. Whatever they are, the machine collects that accurate data. Nobody can interfere with it. Nobody can dispute it. Nobody can tamper with it. And then because you've got some accurate data, you can then start to perform artificial intelligence on it in all sorts of ways. And in health care, of course, as you know, the use cases for blockchain and AI, machine learning are immense. I mean, huge transformational. I do not even know where to start. Counterfeiting of products and drugs is a huge problem that could be eliminated or pushed to the edge with blockchain. Then artificial intelligence can start on the beauty of this. You can start to monitor transactions and supply chains in real time and the machine will run really fast, faster than anything else you can do. You can look at what's happening and keep an eye open for suspicious behaviour or people trying to game the system and the like. So there is a huge amount of use cases, counterfeiting, medical records, insurance claims and the like. It is potentially very transformative. I think a lot of people, including Google, are doing things without blockchain.

But the scepticism about blockchain is that not enough people in blockchain are paying attention to capturing the data properly. They just assume because it's immutable and tamper proofed, that's enough. That's not enough. You've got to capture accurate data and you must put the effort into data. And then the machine will enforce the collection of that data so that you can then start to run artificial intelligence machine learning algorithms on top of it, because then everybody can trust it. So that's where I'm coming from. In medicine, diagnosis, engines and things like that in in health care use AI. The example is some radiology. Using artificial intelligence, scan through images, radiological images, X-rays, is better with AI than with the human. And that's because they've got a trusted data set. Basically, they train it on images, x ray images and with a human that train it. Then it learns faster and it's more accurate than many human interactions. So if you're a radiologist, this is good news because it means you can combine your experience and insights with a machine which will help you not miss things so AI can be super helpful in that context. There are lots of applications in that context. But the key to that is you've got to trust the data. Because it's coming from actual medical scans. The problem is it takes a long time to collect all that data and put it into a format that the machine can then work with, with such a huge amount of data. But you know, if you get it wrong, all the horror stories you've seen in the press where because they've got bias in the system, you know, you get agents spitting out racist. There is a lot of issue to deal with bias and data sets. There is a big problem there. Machine learning and artificial intelligence is super important, super powerful, super transformative and blockchain is a very powerful way of giving accurate and useful data to work on.

Meriyem : You already answered some question. I have other question to go through. You talked about the benefits of blockchain already and the definition.

Julian Fifiield : Blockchain is, it is said what it is. The underpinnings of blockchain are straightforward. Blocks of cryptographically encrypted data chained together, it is pretty much it. It has been around for a long time and has its roots way back 30, 40 years ago. So cryptographically, you take data, you encrypt it. And you chain it together cryptographically, so you got a tamperproof record that builds up over time. And then, of course, it can be used in all sorts of different ways. The most famous way is cryptocurrencies. You can create a cryptocurrency and create a tamper proof coin. My area of interest is using the same underlying technology to create truthful data, truthful digital identities, digital assets, and then start to do work with those digital assets. So the underlying technology is important. It comes from cryptography and computer science. It is all related to truth and trust and verification. There are examples in countries like Belgium and the U.K., you wouldn't be able to do this. But where people are in war countries and have issues with digital identities, putting it on the blockchain because there is no infrastructure, traditional infrastructure to capture your identity, is useful. So you can for example envisage digital identity being captured at birth and recorded as a record on the blockchain, and then over time, that record builds up into an immutable record which you could use to transact with banks or governments or whatever. But that's not technically a problem. So no one's going to be going there for a while.

The potential of the technology is massive. Across finance, health care and education. One of the projects I'm working on is the issuing of a digitally secure, tamperproof degree certificate. Degree certificates issued by your college are not tamper proof. They may not even be issued to the right person. That happens a lot. Fake credentials, fake people, fake credential is a real problem. Blockchain is a powerful way of dealing with the issuing of fake credentials and fake documentation.

Meriyem : I just have had a call with another specialist and he was stressing the fact that blockchain is not a database, like it's a tool and data cannot be stored on blockchain. It is just a tool to ensure trust and transparency around information, is it true?

Julian Fifiield : You're right and he is right or she is right. It's not a traditional database, it's not a database. But you can store data on the blockchain, you can store data and not change them but the perceived wisdom is that if you treat blockchain as a traditional database, you just dump everything into it, especially with these early iterations of blockchain and the way they've been constructed, Bitcoin, Ethereum and the like. They'll be too slow and that grind to a halt. They're very slow and in truth, good practice is that you only store on the blockchain the minimum that you need, to establish the tamper proof record. So, the minimum. It's not a database in that sense, and people shouldn't treat it as such. You're absolutely right. So when you're building out blockchains for different use cases, the blockchain doesn't normally live on its own. It's part of an ecosystem. And somewhere behind the scenes, you've got off chain databases and blockchain things doing their bits. But the bits that's important for tamperproof record may just be the hash. So you're absolutely right. It's a way of conveying truth. An immutable record across the value chain, and it will interact with and govern the rules around that. So one of the interesting thing is that once you set the rules, the machine will enforce the rules. So this will minimize or exclude anybody who's trying to break the rules or read the wrong data because the machine won't let you. You've got to follow the rules, only permitted people only permitted data can be written in. So that's a good point.

Meriyem : Within the literature review, I was often reading that a private blockchain was often better than public blockchain in the health sector, what do you think?

Julian Fifield : Yes, that's right, that's correct. I work in private projects primarily. My work is mostly private. And that's because, there's a number of reasons. The private blockchain are, when you are dealing with multiple stakeholders in a value chain, they often do not trust each other (...) there is a kind of collaborative governance structure, which means people do not have to trust each other because they have agreed the rules of exchange between them. And the private chain means only those who have committed can join in. So all the data is not public. It is contained within the value chain. And everybody agreed the rules So they trust it. The machine enforces the trust. And of course, because you do not have data mining and all that stuff with Bitcoin, it can run as fast as you like. Although even today, even with the private blockchain, they do not run as fast as some of the traditional financial databases. It doesn't run anywhere near as fast as Visa or MasterCard or anything like that. But they are speeding up and then becoming faster, faster. But private chains are very good for supply chains. They're very good for value chains. They're very good for traceability and provenance. They're very good for when you've got farmers, producers, distributors, retailers, consumers, this kind of environment. Bitcoin as a business model is probably bust, probably bust because the energy requirements. That mode of is bonkers, is bonkers. I think it's heading for a bust unless they can fix that, which they are desperately trying to do I know.

Meriyem : And about healthcare, if we want the patients to start sharing and owning their own data, would it be difficult to have a private blockchain if every patient needs to come into the system? Isn't it better to have a public blockchain in health care?

Julian Fifield : I think that's not necessarily the case. If you use the blockchain infrastructure to create a medical record at birth and that medical record was given to the patient, obviously a baby can't operate the medical record, but the parent could be given permission to operate their medical record until the baby, the child got to the right age, whatever that age is. That's a rule and the blockchain medical record is set up such that you require the patient, all that guardian, up to a certain age to give permission to the hospital or the clinic or the GP to access that data and to read data. So there's no reason why that couldn't be contained on a public blockchain. There's no reason and technically no reason because the rules of access would be governed by the blockchain and the patient would have to give permission to share that data. So it wouldn't be a huge difference between that approach and a private one. So you'd have a private one per health system. The UK would have one. Belgium would have one and potentially what you could do is if I visit Belgium and I need to share my medical record with a doctor or a hospital in Belgium, because I fallen ill, the issue will be interoperability, of course. So you'd have to have European wide rules about what the interoperability frameworks are like. Blockchain has to be interoperate. So the UK blockchain would have to speak to the Belgian blockchain. In principle it is not a problem. I think given the nation states and all that kind of thing, it's unlikely, unlikely to happen, probably. People prefer at this point, private channels. Well, I suspect that will change over time. The zero knowledge proofs are very important. There's a lot going on with blockchain there. You can make knowledge available to somebody saying, I travel to Belgium and the customs officer at the border wants to know that I am who I say I am. The blockchain can deliver that proof. But without giving any information to that customs officer. You can't do that with any other

technology. So I can turn up to a border with my blockchain identity and I can give it to the border officer and the border officer will scan it and we'll get a verification that I am who I say I am. But they won't know anything else. They won't know how old I am, where I live, what sex I am, anything.

Meriyem : So the privacy is respected.

Julian Fifiield : The privacy is respected, yes. That can be done already. The problem is, again, a lot of these issues aren't technical. They're political. The problem is that everybody wants to know where you were born, what age you are or what, and that's because we do not have any identity. You do not have a verification identity. One point of identity, nobody got a proper identity. You have to have all these different checks and balances in the system to basically prove your identity. With blockchain, you could eliminate all of that. You can just have one proof of verification, the blockchain that will deliver the information to you, and you wouldn't have access to any other private information. But politics is what gets in the way of that, that's not technical stuff.

Meriyem : And I have another question because as we know, like blockchain kind of begins within the financial environment. And so in the literature review, it's not always clear. But if I understood correctly, with what you are seeing, there is not like a kind of consensus protocol, such as the proof of work for every activity? It depends on the activity and on the application.

Julian Fifiield : That is correct. On a project I worked last year, there was no consensus required. There's no proof of work mechanism. You do not need that because effectively the rules, the ground rules, the authentication is built into code. So that means you can run instantaneously and there's no proof of work required. And those traditional consensus mechanisms aren't required

Meriyem : And there is no validators then as well? How we can validate a transaction?

Julian Fifiield : If you can engineer the blockchain to do something. The validation requirements are built into code. They're in code and they're hard coded. So let me give you a very concrete example, but not from health care. Although you could use one from health care. Let's say you're manufacturing a drug. They want to prove to the patient or a doctor that it is what it is. So you would go for the validation and authentication layer. What is the product, what does it contain? Where was it manufactured? What is the badge number? You know, all those kind of things. There's like a layer of authentication that you go through to prove that that product is what it is.

Meriyem : So no need of a person to validate it. It is completely thanks to the rules that have been established before?

Julian Fifiield : Correct. Someone has to write the code. The most important thing is the validation. So a drug or a product, you've got to have this validation and then that gets encoded. And it can't be corrupted. If you're manufacturing a product, for example, in factory A, with components B and timestamped C and whatever it is. You then start to try to do something. The machine will throw it out. You're not allowed to manufacture that product because it's not in the right factory. It could be as simple as that. People often talk

about blockchain as a governance agency, but it's enforced by a machine, not by people or a central authority. That's a very different thing. You do not need people to do this. The machine will do it.

Meriyem : Now I think we can make the bridge to artificial intelligence. So as my question is, seeing how blockchain can positively impact AI, I wanted to know what are the several issues around artificial intelligence. So you already mentioned bias, discrimination, data that are tampered or not. I have also noticed other issues such as governance and legal, privacy and cybersecurity, trust issues from, for example, the patients or the doctors who are going to use the machine or have diagnoses done by the machine in the future as well as transparency and explainability with for example the fact of being able to explain the decision taken by the system. Then the data issues, as we said such as data quality, availability and provenance. Therefore, I have some question to see if blockchain can help with those issues.

Julian Fifield : If it is done right, I think it can help with a lot of those issues if it's done right, it can help with identity. Because effectively you can catch your identity properly and then make that into a truthful record. So this might help with identity, capturing the truth, minimizing or eliminating dirty data problems because the machine won't allow dirty data into the ecosystem, thanks to blockchain, because they're safe and secure. And it won't allow dirty data to go in because the machines won't allow it. And privacy, you can engineer privacy such that people only need one point of verification because the machine has got all the other verification items. So in the case of as I said earlier, you can have a code on your smartphone, which can be scanned at the hospital or scanned at the border, and it will only allow out the data verification. I am who I say I am and it won't tell anybody. That's a very good way of being private. So blockchain can help with many of those issues that you've raised If it's done right.

Meriyem : Can we go now through every issue AI faces and maybe tell what you think about the potential solution blockchain can give and then I will finish with some question about the possibility of this implementation in the future. What do you think about the accessibility?

Julian Fifield : Accessibility means for me we can make data available that either another machine or a human can read in a much more accessible way than now. Because a lot of data is produced by databases, small and large. This is basically gobbledygook. You need to have sophisticated tools to understand the data. You've got to be able to run third party business intelligence services on top of it. Even data like Excel is not easy to use sometimes. So I think because you're collecting truthful information, you can construct dashboards which make access to reporting, events and other things easier. So I think actually done right, you can improve access to data. You do not need to go through the linear old loops that you do with old traditional databases, trying to make sense of data coming up from Oracle database. This is really hard work. Really hard work so the machine can straighten all out and automated reports.

Meriyem : Right and what about discrimination in AI which can exist for example because we do not have enough data from the emerging countries, from people who do not have the same technological means as we have. Can blockchain makes that people will share

more their data thanks to blockchain and make that we can train AI in a better way? For emerging people in emerging countries and not provide biases. Is it possible?

Julian Fifield : I think so because to use a blockchain, it forces you to go through this process of identifying what the data points are and what the truthful data points are. It forces you to do this. If you do not do that effectively, you've got untruthful, dirty data passing through the system, just like you have in a normal database. So again, done right, it forces you to address the questions up front. You can overcome some of the biases at the beginning. You do not just take the dirty data for granted. You can think about an open and transparent way, what you're trying to collect, why you're trying to collect it, how you collect it before you start. So you should go through the open and transparent process. Make sure that you're not being biased or you're relying on biased data. Because effectively you're able to pool in and agree in a governance framework exactly what a trustful and non-bias data looks like. There is this big problem in education. CVs which are automatically scan by machines and have a bias against people with names which might come from the black community. There is a bias. The machine isn't biased. Those rules were written by biased people. So the algorithm reflects the bias of the people and reflects human bias. Submit a CV to a company with a name which comes from the black community, there's a lot of literature that say there's more chances of that not going through the system than if you have a name from a white community. Yeah, this happens a lot. In institutions around the world, there's bias. My view is if you can have an open and transparent process so that those biases are acknowledged, dealt with, they're on the table, you mitigate them (ageism, sexism, racism), all those biases can be effectively eliminated through a governance mechanism at the beginning.

Meriyem : And this will be provided by blockchain, this governance mechanism to avoid it? I do not really see the link with blockchain and at this time.

Julian Fifield : Well, I suppose the truthful answer is you do not need blockchain either.

Meriyem : OK, so here a blockchain cannot be related with A.I. at this part. We cannot use blockchain to reduce discrimination done by AI.

Julian Fifield : No, I wouldn't say that. I think you can help that out by agreeing the rules. Of data collection and eliminating bias upfront, and then you have a tamper proof record. So I think it could help. Absolutely. Well, it's not the only way of doing it. There are other ways as well. It's not essential.

Meriyem : Yeah, OK. And about the trust improvement I have seen in the literature review that there is a lack of trust in the AI system from the end users, doctors, patients, etc. One of the explanation is the fact that they won't trust it because it's a machine who is doing, for example, a diagnosis or something else and not a human. And they trust more a human than a machine. How can blockchain improve that trust?

Julian Fifield : That's my main thesis. It's not the only way of doing it, but I think it can. The evidence of some of the case studies is that the machine is better at diagnosis than the human. What does the patient want? What's a good diagnosis? Let's say the machine is better than the human. Which would you choose?

Meriyem : The machine.

Julian Fifield : Now, the problem is it's very, very, very, very early days. Very early days in blockchain and very early days in machine. And if you go to the doctor, everyone has an experience where the doctor actually doesn't know what they're doing because they're only human and they make mistakes and they're not experts in everything. So everyone's got examples of that. I think we're a long way off having machines doing all the work, because we're sociable people. We want to talk to somebody. But you've already got examples of machines working with people to eliminate, to help eliminate mistakes, false positives and false negatives. So these things will only gain in time and therefore, trust will be. We'll grow in time and it won't be long. I do not think it'll be long before when you go to the hospital, you're talking to a human, but there's a machine sitting side by side with the human giving, helping the doctor. That's ideal. But I think blockchain can help gather the accurate data and the like. But as I said to you earlier, it's not the only way of getting it within the system. At all. So it will vary depending on the use case. But within the health care environment, it probably not going to help with X-rays. If you go to the doctor and you want to be given the right drug, blockchain may help that interaction by saying, I can guarantee you 100 percent that the drug I'm prescribing is the right drug because it's controlled. Which is not the case in many parts of the world. You go to the clinic or a hospital for a drug. You do not know if you get the right drug. You do not. It's a real big problem in Russia. It's a big problem in Africa. It's a big problem in Asia and it's a smaller problem but it's still a problem here in Europe. You do not know. So blockchain and AI could work together really well there because there's a nice use case for manufacture, for production of things. But it isn't going to help with X-rays or similar things.

Meriyem : And I have also another question about explainability. So as I said before, they are saying that sometimes if a decision is taken by a machine, then the doctor won't be able to explain the decision because there's a lot of variables which are taking into account. When we fed the data into machine, they have a lot of variables and it's a lot of mathematical stuff.

Julian Fifield : The blackbox problem

Meriyem : Exactly! And so I was reading that maybe as blockchain can trace and track all the steps and all the decision that the machine has done during the process, maybe it will be easier to go back in the ledger, in the blockchain ledger to see what happened and then explain how the decision has been taken. Is it right or you think that blockchain cannot help at all to increase explainability of AI.

Julian Fifield : That's a very good question. The black box problem is a problem. But you've got a black box problem anyway. You've got a black box problem now. It's called your head. It's a black box. If you go to a GP, you're talking to a black box head, you do not know what's going on in there. You have no idea. But the GP will try and explain to you what the diagnosis is and why you've got a lump or you've got a fever or, you know, the black box, the head, the GP tries to explain it to you. And therefore, you have some insights into what's going on in the black box. So you could have something similar with a machine black box where the black box doesn't just give you a diagnosis, it explains to you why. It will just illustrate on a confidence level, on 98 percent sure, this diagnosis is this and the reasons are high blood pressure, etc. They've taken the data and give you the answer and give you percentages and give the explanation to you as a patient. I think those black boxes

can be more accurate than human ones. Because with a human box, they make mistakes. That confirmation bias. They have misdiagnosis, it happens all the time, all the time. Go home, You've only got a cold. It turns out you've got something really serious. Done right, I think machines can be better at diagnosis, capturing all the variables without bias, without resting, not having a day off of things, but that's a long way. But that's the Holy Grail. That's what people are working on with AI. But there's no reason why a blackbox can't tell you this is the answer.

Meriyem : So blockchain cannot really help to explain according to you. I mean, as every steps can be registered in the blockchain ledger. Maybe I'm wrong.

Julian Fifield : I do not think you're right or wrong. I think you're ahead of the time. I can't see a way of doing that at the moment, but maybe that's me.

Meriyem : No, I mean, it's clear in the article that they say that it's so new that there is not a lot of literature about it. So actually, I read a lot of articles to see how the two of them can merge. It's difficult for me to find answers to my questions. But you already gave a lot of answers. I wanted also to talk a little bit about the issues that we can face by integrating these two, like, for example, about intermediaries. Can removing intermediaries between information and artificial intelligence system be a problem? They were saying in the literature that blockchain can remove the power in the GAFA's hands and put it in the patient's hands, for example.

Julian Fifield : That's true. I see your point here. No, there is definitely scope within blockchain solution to cut out some of the bits in a process that exists now. So you can capture that information and make that directly available to the to the consumer, for example. And you do not need some of the people in the middle to process. You certainly can do that. You can take out intermediary steps. You can concatenate and press the value chain.

Meriyem : Yeah. And actually it can be better for AI because, for example, I was reading that if I am a company and that I want to create an AI system, creating an AI system is not a challenge anymore. The challenge is really to gather data, but they are in the hands of big companies. They will maybe be able to develop thanks to blockchain new system as well as in not only the GAFA companies would be able to produce like an AI.

Julian Fifield : I think in some ways that's right. The artificial intelligence engines are much more advanced than they used to be. And they're open source, a lot of them. You can use Google's AI engine. The AI is increasingly a useful tool if you can get access to the data. You're absolutely right. But intermediaries exist because of historical analogy. Steps in supply chain or a value chain. So you get aggregation points or distribution points or allegedly they add value to a process. Often they do not. They're adding costs and getting in the way. So there is a very powerful potential to take out some of those people and blocks and costs.

Meriyem : And could scalability issue prevent the blockchain use for AI as this technology requires a lot of data and a lot of storage space? Because I read that blocks cannot contain a lot of data but AI needs a lot of data. So can it be a problem?

Julian Fifiield : Scalability is a problem at the moment. Transaction speeds and the ability to press the stakes are very high speed and it is increasingly available. So you kind of got that. The ability to securely reference data that's held off chain can be a way around it. But the point is, blockchain isn't trying to duplicate and just make a better database. It's not trying to do that. It's trying to do something else. So effectively, as I said, blockchain doesn't exist on its own. It normally works in an ecosystem of data and people. It exists as an ecosystem. It's only a problem if you think the job is to create a new kind of database. It's not, it's a new kind of truth. It's a new kind of authenticity. It's a new kind of proof and a new kind of trust. That's what blockchain is about. But the blockchain will enforce the rules for the database. So blockchain is the supervisor, the governing agent, and will prevent abuse, as it were, by the traditional database. It's a governing agent. It's a governing framework. I would imagine there will be massive improvements in data and block size anyway, and that's just a question of time. I'm sure that will improve a lot. But we're only a few short, short years into use cases here. It took 15, 20 years for the Web to become really meaningful for lots of people. Actually now the acceleration times are dropping. It's not going to take 25 years. The whole artificial intelligence block channel get accelerating, it's much quicker than it was before, and Google are moving really fast in these spaces. So artificial intelligence, as say, is already routine now in lots of areas, all phones depend on artificial intelligence every day. If we have the conversation in 10 years' time you wouldn't have the same questions.

Meriyem : Yeah I guess. I read that blockchain can face a security challenge as well. So if we use the public blockchain, then with the 51% attacks, for example, if 51% of the network owns the power, and with the private blockchain it is just the one who owns it who can actually decide to change something in the information.

Julian Fifiield : It is like in any other technology. There are security risks, availability risks, hacking risks and the like, although no one's ever hack blockchain.

Meriyem : So it's more complicated than a normal system.

Julian Fifiield : No one's ever hacked the blockchain, but they've hacked some of the exchanges and distribution points and stolen things. But you can't hack blockchain today anyway. So there are security issues. But remember, in a private permission chain, the rules, who has access, who can see, who can read, who can download are governed by the machine. And if you write the rules properly, they are a scale more secure than traditional systems and databases and people. I would argue that the security issues are still there, of course. I mean, all these things are held in the cloud. But one of the things is there's no single point of failure with the blockchain because it's distributed across all of the actors and the stakeholders. So if you were a node in the blockchain and we lost you and we lost your data, the machine is still there. It's almost impossible to get rid of the blockchain once it's built because it's all over distributed and you decide how many distribution points there are, how many nodes there are in the system. So personally, I would argue if you look at the risks people are running now. Security risk that people are running now with their data, they're running very high risk. Dirty data, hacking ability for internal stakeholders to compromise the data, ability to download the data, and leak it. All of those things could be massively improved if a machine was looking after it using tamper proof methods. So I think it's a move in security. I'm not saying it's risk free. Nothing is risk free, but it's gotten better than what we've got at the moment. The banking system and the

movement of money globally, it's riddled with fraud. Riddled with fraud, hundreds of billions of pounds of fraud. So we're running really risky systems now. But that's really scary for the banks. You've got to understand risk in context, big security risk, lots of risk now. Lots of problems. Lots of issues, fraud. Blockchain can eliminate a lot of that. It comes at a price. You might lose control of your currency. Governments do not like that. Have you been following the Libra story? Mark Zuckerberg has been written saying no way we can allow you to issue your digital currency. So they're scared, petrified of it because you could see Mark Zuckerberg becoming the most important player in money in the world in a short period of time. they won't allow him to do that. And that is because it's blockchain. Not because he has got a better database. Blockchain is a subversive and disruptive technology because of its tamperproof nature in whatever way, wherever use case you've got it, and digital currency is one of them, but it's a subversive and disruptive technology. And it's really challenging for people. People do not really understand why subversive. But it is, it is subversive because it's immutable and a machine will govern who can do what and if you do not follow the rules, you're out. Unlike in our current system, there are lots of ways that humans can interfere in that process.

Meriyem : It's really interesting. And now just to finish it, the last part is about the technology acceptance model. The first one is : Does the integration of the two systems enhance doctors and other end users' job performance? Can it help, for example, a doctor to do a better diagnosis or patients to have a better treatment?

Julian Fifield : Yeah for sure.

Meriyem : Would the integration of those technologies together enhance AI and physicians' performance ? Would it be easy to use and to implement?

Julian Fifield : Near time, it won't be easy to use. But over time it will become easier to use because the machine, instead of relying on analogy models of interactions with machines and databases and stuff, the machine will do a lot of the heavy lifting and will do the work for you so it will become easier to use over time.

Meriyem : OK. Do you think that blockchain use in AI is understandable and clear?

Meriyem : No, no, not yet. We're still very early.

Meriyem : Do you think that improving Blockchain literacy to people will take time before being able to use it for AI?

Julian Fifield : Oh yeah, a lot. there's not an issue to do with the technology, the barrier to entry is people. They do not understand it, they do not, you know, they're not familiar with it and they're scared of the future. But for use cases around AI and blockchain, the technology is not there yet. So those barriers are people, not technological.

Meriyem : And what is your feeling, your impression about the implementation of these two?

Julian Fifield : It's very, very, very early. The point is R&D at the moment. R&D, it's not real world use cases. It's in the lab. We have to remember the context, health care is very

conservative. It's not a rapid adopter. In any event of any technology. It's not an innovation space, it's not an innovation space at all. Google got into a lot of trouble. I do not know if you read about the case. They agree the data deal in London with a major hospital. The hospital generated the data from patients, anonymized it and gave it to Google to play with. Google got to a lot of trouble. As did the hospital. I think I can't remember exactly the reason why. This issue of data privacy. Even though the hospitals themselves are not very good at data privacy. That's the real paradox, you know. Anyway, the health care systems are not innovative engine rooms for change. They are very slow. They do not adopt new technologies and techniques even when the use cases are right in their face. It's always going to be a problem. However, here's the thing. Here's an example. If I go to London, I can go to Victoria Station, it's one of the main train stations in London. I can go to London and I'm going to a health care clinic. I can get an MRI scan. A scan while I wait. I can see a specialist while I wait. I can get a diagnosis really quickly, yeah, on demand. Even now, I can do that. But, it is slow to change. We're going to give up, we will give up trying to change the health care system because we're all dead and we're tired. We're going to stop trying to change the system. But if I said to you what we'll do is we'll appeal directly to patients, come to us because we put up a system relying on artificial intelligence, which is better than what you will get in your local health care. I would go to that wouldn't I? If I was assured that this new service was better than the old service, I would go to the new service. There could be innovation outside the system. But I suspect that won't happen. I think there are very individual use cases around radiology and diagnostic systems which are being worked on now. They may well come in. They may well come in to assist, I think in this particular health care verticals, when there's a diagnosis problem, machine can help with a diagnosis. So that could be very interesting and maybe there could be some of these medical adoption. But in terms of the overall service, it's going to be years and years before anything meaningful happens and there's going to be huge punch ups over data.

Meriyem : It's related to the question which is: do you think that in the future there is a high potential and a high probability that these technologies end up together?

Julian Fifield : I think it's a convergence, but not for a while. That's quite a way off. They are two separate activities at the moment. I think that may well converge in the future, but that's a long way off.

Meriyem : I have a last question, what about the development of those potential technology together in the emerging countries? How do you think it is going to evolve there?

Julian Fifield : Well, interesting question. I'd like to say, I think that actually that could be the case. If you do not have legacy infrastructures, you do not have legacy systems, you do not have legacy politics, you do not have legacy medicine. You do not have legacy services. An example with technology on that is EMPISA, which is a payment system that was used in Kenya. Which meant that people wouldn't have a bank or any money because they actually exchange value on their mobile phones. So electronic transactions on the phone peer-to-peer were years ahead of Europe and America. So brilliant example of technology helping developing countries, reinventing the old wheel, construct the new wheel. But there was a use case you might look up just recently with Google. Google came up with an algorithm and a camera app. I'm trying to remember what it was for. I think it was Google

deepmind. I think it was to do with kidney disease. And so they tested it in the lab and it worked really well. And then they went to the field in the developing country to test it and it all went wrong. And it all went wrong because the conditions, the actuals on the ground, physical conditions were so bad. That was not a technological problem, it was an implementation problem. We couldn't actually use the technology. It physically couldn't be used in a meaningful way because the conditions are so bad. So whilst I'm optimistic about developing nations leapfrogging and not making the same mistakes that we've all done, there are other issues to hand. Chaotic politics, lots of other conditions which do not relate to technological use cases which get in the way. So I'm afraid it won't always be the case, unfortunately, that developing nations can leapfrog. If you look at broadband adoption, Tesla have launched a new service called Starlink. All these satellites, which means if you're in the middle of nowhere, there's no telecoms and there's no infrastructures and there's no broadband in the ground or anything you can get a faster signal than I can here. Brilliant. I'm sure they'll be able to adopt that. Why spending a lot of money on old fashioned wires and fibre optics when you can get it straight from the sky. So I think there will be a lot of adoptions in that place, but not necessarily adoptions in health care, because I think it's a bit messier.

Meriyem : So for you in the emerging countries, regarding what we were talking about blockchain and AI will not be more difficult to implement than in the western countries?

Julian Fifield : I think in some use cases it will be easier. For example, I'm working on a discussion at the moment with South Africa where we're looking at trying to prove the provenance of their citrus fruits. I think they will be better and faster adopters in that case than in the developed world where there's too many barriers, politics and all sorts of problems and legacy thinking. In this, they'd probably be a bit more entrepreneurial. So I think there will be some use cases where they are positive adopters, faster than any other developed nations. But in other cases, it is going to be a mixed bag.

Meriyem : Perfect, thank you for your time

Julian Fifield : With pleasure, have a nice day.

Meriyem : You too.

Interview Bill Inman

Meriyem : Hi Mr Inman, how are you?

Bill Inman : Good, thank you very much.

Meriyem : Thank you for joining the call. I will present myself quickly. My name is Meriyem and I am a second year master student in Business Engineering, in Belgium. And I am finishing my master with a thesis about how blockchain can impact AI. My question is *"Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence?"*. Could you introduce yourself, your relation with blockchain and AI as well as with healthcare?

Bill Inman : Right, I'm the CEO of Singularity Studio, the Enterprise Solutions Company that is leveraging the singularity in that platform. I work directly with the SingularityNet Founders every day.

Meriyem : OK, I already made a call with another person from Singularity, U.K. You are one of the company which are using blockchain for AI, right?

Bill Inman : That's right. We leverage blockchain for AI in at Singularity.

Meriyem : We have 30 minutes. So I will immediately dive into the subject with the first question. What are the most kind of use cases for which you are using blockchain for AI?

Bill Inman : Well, data, for sure. As being an immutable record of data from an enterprise perspective, it allows us to confidently leverage A.I. and the data sources to make sure that there's less bias, it's more accurate and so forth and more easily connected. But how we are using Blockchain with A.I. at Singularity is that anybody in the world after proper approval can post their AI agent into the singularityNet platform. And it's tokenized so people actually get paid through the AGI token and by usage. So the more their AI agents that they post are used, the more they get paid with tokens. So this decentralized model, crosses borders and crosses company size. Individuals can post their agent enterprises, can post a free agent. So being decentralized and using the token to incentivize people allows us to do something entirely different with A.I. It can help to bring disparate AIs together into one platform that can be compounded on top of each other to create new solutions. But does that make sense?

Meriyem : Yeah, it makes sense.

Bill Inman : OK, well, the alternative to decentralized data is big tech A.I., Google, Deep Mind, Tencent, Alibaba, Amazon Web Services and of course, there is basically the layer on top of those enterprise solutions. And you're limited by the creativity and the architecture and the security of the centralized platform. So decentralized circumvents all of those challenges, the talent needed to create AI on the platform, the lack of ingenuity, being centralized or centralized governance,... And also there's the potential for these enterprises to do either unwillingly or unknowingly or knowingly nefarious things with the data and with the information. By having it decentralized, there's not one enterprise

that's in control. It disperses the control of who's operating in the AI into individual segments.

Meriyem : And do you have any other use cases or it's principally the one that you're saying?

Bill Inman : Well, right now, it's the one that we're leveraging. Data, of course, on the blockchain to be accessed, whether it's public data or whether enterprises want to leverage their information to be sold, when they want to secure part of their information. The blockchain is a great use case for data to be leveraged by, so that people can actually monetize their information and also combine information because we need the fuel for artificial intelligence. Without that, it doesn't work very well. There's a whole bunch of different techniques that are being used in AI now to use less data, to create models and train models.

Meriyem : And can blockchain help to facilitate the accessibility to data for the machine.

Bill Inman : Absolutely, I'm talking to a company that is creating a platform to easily connect your data into a blockchain based AI data network. It doesn't have anything to do with the actual algorithms. It's just the information. So it absolutely can, because you know, there's a lot of data around the world, whether it's at a mid-sized company or an enterprise or some other type of organization or even individuals. They do not know how to monetize their data, how to get that out there into the field. So having a platform, a block based platform that creates security and accessibility without threatening the anonymity of the data or making all the data public is a great way to leverage blockchain for AI.

Meriyem : Yeah, so it can give access to data to smaller companies, which maybe have the means to create an algorithm.

Bill Inman : Definitely. Definitely. So one of the projects that is in the early phases for us is agriculture based and its carbon sequestration to store carbon, physically storing carbon that's generated from manufacturers and other businesses that create carbon into the ground at farms and ranches. There's tons of ways for local data gathering, whether it's agriculture, whether it's finance, to sell that information and make money or to provide that information for global studies and just do good and maybe get credit for it.

Meriyem : OK, and if we want to use the AI machine with the data on blockchain, does that need to be on blockchain or can we take the data from blockchain to put them into AI?

Bill Inman : AI won't be on the blockchain because there's no reason. I mean, AI can run in a decentralized manner, you know, leveraging different types of decentralized computing efforts to increase its power. That makes sense. That's not necessarily blockchain though. That's a decentralized computing. But what AI can do, especially for purpose of AI or explainable A.I., is that it can store its information and whether it's biased or not, it can look at what it's shown over time and be explained in a blockchain. So that way, there's no question that this A.I. said this about this. Let's go micro banking, for example. So AI said to fund these projects over time and this is where the money should go. But if we find out over time that the trend is that it's biased towards a certain

geography or socio economic, that type of information or metadata from the AI is way better suited for blockchain. So we could prove that it's explainable and unbiased over time.

Meriyem : So it came up with transparency and with traceability.

Bill Inman : Yes, blockchain is the technology of trust because of immutability, and it's a great opportunity to store that in an immutable record.

Meriyem : OK. And for example, if a decision is taken by a machine, I would say like, OK, the machine came to the decision that the patient has a cancer. Can it help to explain, can the blockchain store the steps that the AI has taken, or is it impossible to explain the decision?

Bill Inman : It should store the results. Blockchain should be used to store the results for every transaction, like the end results and how it got there, what are the data point. So let's say that there is the choice of ten data points to come up with the decision, but it only uses eight of them as opposed to ten, because that's just what it means. Then the 8 data points that should be stored on the blockchain plus the final result so we know what variables and what data inputs created what result. And over time, we can take a look at that with maybe other AI agents to say, well, that was biased towards this type of person or this type of affliction or disease or we may come up with the results that it just works better for this type of cancer. So having an immutable record allows us to, with trust and with beliefs, understand that. AI agents like blockchain to store transactions to be trusted. Not that they're unethical, although some AI might be because there programmed to be it, but just because it's better suited to do. The algorithm was better suited to do this. And here's the proof. Without that proof, then you have metadata that could be manipulated and then people want to sell their AI saying it's better suited for breast cancer. Here's why. But how can you trust it? It is not immutable.

Meriyem : And so it can help with unfair biases, then?

Bill Inman : Yes, explainability, transparency and explain any bias or showing bias.

Meriyem : OK, and also if we ensure that the data are untampered and then we are going to use them for the machine. It prevents also from bias?

Bill Inman : Here we go.

Meriyem : I was reading from a study that the trust from the end users in a machine is low. How can blockchain help to increase that trust, if it can?

Bill Inman : Well, blockchain, it is going back to this main point, it's going to store the results and the variables that made the decision over time. By the way, we do not need to see the full record. We could just say this 48-year-old woman had breast cancer, she was a smoker. Here's what we know about her diet. And that information can be published for public use, but we can track that over the forty-six or forty-seven, forty-eight, all these different people over time. And we can see that, oh, that was biased towards women in North America. But for women in Europe, that doesn't really apply. Without the

immutable record again, it's hard to combine data, much harder to combine different data transparently or even anonymously. But this really will help with the trust around the decision making process, whether the AI was biased or not. And it helps with transparency and explainability.

Meriyem : OK. And can it help to do personalized treatment and diagnosis if we create a machine that helps with diagnosis and then we feed AI with personalized data for having more accurate and personalized treatment.

Bill Inman : Eventually but we're not there yet. Blockchain gives the power to individuals to share their data or not. It allows for somebody that has a cancer for example, to say, yes, I want my data to be published and yes, I'd like to be paid for it. So as Blockchain matures, the individuals will be able to make that decision and they can either share their information or not based upon what their decision is. So it can help a lot for personalization because somebody can either donate their data or provide more of their data to third parties that companies can't have. You know, companies in the US, they're open to lawsuits for sharing data. However, if they store the data on the blockchain and we say we push that decision to share your information and that it is in the patient's hand, it allows for the possibility of more freedom based upon the individual approving or not.

Meriyem : OK. OK, it makes sense. What about the potential issues or challenges that you can face while trying to use blockchain for AI.

Bill Inman : Well, first of all, it's not proven that enterprises want to store their data in the blockchain for AI. It's not proven that enterprises want to bring out bring in third party AI so without knowing exactly decentralised that is, without knowing exactly how they were created. I mean, certainly nobody wants to be hacked or anything else that some other kind of disruption. So decentralized isn't proven that the companies want to share their data yet through a decentralized model. It also it's not completely proven that companies, enterprises, especially big companies, want to leverage decentralized for their own business because many of the decision makers, even up to the CIO level that businesses want to and are comfortable working with IBM, Amazon, you know, Tencent or whatever the case may be in the various countries because if they make a decision on a small provider, their job could be in jeopardy. They're quite often much better going with this, with centralized because basically Amazon is.

Meriyem : Yeah, yeah, sure. And is there other issues or that's the more important one.

Bill Inman : Well, over connectivity, you know, right now to in order to be decentralized, you have to have an API and an API of APIs to be able to take your enterprise and plug it into decentralized A.I. You know, there are forty-five hundred artificial intelligence companies that have been funded with 80 billion dollars since 2014. That means there's forty-five hundred different solutions out there that a CEO needs to know how to navigate and leverage. So until there's a real ecosystem of decentralized AI that can be brought together, once we know the problem, they're not easy to access. That's part of what we're doing, a singularity studio, but we're still young. So being able to find that qualify decentralized AI solutions and then bring them in securely into the enterprise is not as easy as just going to Microsoft, saying, I'm going to use Azure and what you have available

Meriyem : Yeah, and what about the interoperability?

Bill Inman : Well, right now there's a blend of cloud based solutions on premise data and that may be stored at the AI provider itself. So enterprises are not extremely enthusiastic just yet about storing their data at the AI database because for security purposes. They do not want it to be stolen or even leaked. So there's that connectivity between the A.I. itself and the enterprise. So that's the first level of connectivity. That's what I most people to say "well, I'm on Azure. I'm just going to use whatever AI tools they have or I'm on Salesforce for sales and I use their AI. or I am on NYS to use their tools because they're comfortable storing their data in the cloud". But a lot of companies have their data stored on even old and even super old systems, that it's not easy for them to unlock the information for AI. So first you have the interoperability of just taking the legacy internal enterprise system and then making that available to the AI to use. And then on top of that, there are so many narrow AI that do very specific things, some for computer vision, some for natural language processing to be able to combine those AI right now. It takes a lot of custom work inside of the enterprise to bring all those pieces of a car together to make a car. There simply not enough AI talent to do that around the world. There's a lack of a talent level and data scientists. So being able to connect the data interoperably, being able to integrate all of these different AI that are already pre-built is tough because there's no enough talent. And then if they wanted to create their own proprietary AI enterprise, they're often reinventing the wheel and just blowing money because all these things have been created. They just didn't know what was out there. So there's several different layers. But interoperability challenges are obstacle.

Meriyem : OK. OK. And the last part is about the TAM model. But first can blockchain helps to take joint decision?

Bill Inman : For joint decision making, blockchain is the information, AIs are the algorithms that provide insights. Combining AIs often leads to different types or even maybe even breakthrough insights. So that's how they can jointly create decisions. Blockchain provides the information though.

Meriyem : OK. And the last part, the technological acceptance model is just to see how both technologies together can be accepted in the future or even now. So the first question is: would the integration of these two systems can help to enhance the AI and the user's jobs performance?

Bill Inman : The answer is yes, if the AI solves the problem for the company, then that should provide insights to be able to drive productivity. That's why they use it, I think. But they need to pick the right AI, integrating it the right way with missing points on the person or other AI agents they could use. You know, a lot of mid-sized companies can't afford to use Azure or EWS solutions and their solutions are too expensive. So having Blockchain on a decentralized level, it helps the market because it drives down the costs. Different AI that aren't behind or attached to a platform that could be costly can't be leveraged. So it certainly has the opportunity to make everything more accessible because of cost. Now, once AI decentralization matures and is very simple plug and play model and there's this API of APIs to bring together all these different APIs of all these agents, connect them, overlap them, it will be great. That's the plan, it is to orchestrate multiple AIs, to do new things on a real time basis. Then it will be more powerful than the platforms

because the platforms are limited by the security of the governance of their enterprise, the Amazons, Microsoft and so forth. So it will be more accessible. But Enterprise, decentralized A.I. is not there yet. It's in early phases as all AI such as IPO is an example of a centralized A.I. and that took many years for it to become useful to governments with very basic insights on existing data. We're in the very early phases of decentralized A.I. But it will make AI much more accessible and cheaper once we get there. We're not there yet.

Meriyem : Would it be easy to use and to implement or is it difficult?

Bill Inman : It will be very easy. It has to be very easy to use and implement. Simply connect your information source via API into decentralized A.I. Once you're there, you need to know your problem, speak a problem, type a problem into the GUI and then behind the scenes, this is the vision, AI orchestrates all of the different AIs together into one solution, like a Lego set, it brings AI actually together based upon the problem and solves it without any human intervention, any human code. That's the ease of use that we need to get to.

Meriyem : But for the developers, at Singularity, do you find difficulties to implement that kind of new technologies together or you do not face that much difficulty?

Meriyem : Singularity already has blockchain for incentivizing A.I. That's already built and you can connect an AI into our platform, so it's already done, actually. So I wouldn't say it's complicated, but in order to make it easier to use, that's an evolution that gets better over time.

Meriyem : OK. And do you think that for now, blockchain for AI is understandable and clear?

Bill Inman : « No, I mean, we're still in the very early stages of both, but this decade, A.I. is expected to add 15 trillion dollars to the global GDP, the global domestic product. And we're going to evolve very fast. Blockchain is still trying to find its way as an enterprise product period. Right now it's basically a fintech novelty. Blockchain is not easy yet to be used.

Meriyem : Ok, and do you think that improving blockchain literacy to people will take time before we are able to use it for AI?

Bill Inman : Well, no, I do not think literacy matters. As long as it's easy to plug in information into the solution, nobody needs to know how it works. I feel like they need to understand how the decisions were made, but they do not need to know the inner workings, it's got to be like a browser. We do not ask how the Internet works when it serves on the Web page. We just read the Web page. So that's the ease of use that we're getting to. Nobody's going to care about how it does it, but they are going to care about whether it was biased or not.

Meriyem : Yeah, OK. And will the benefits outweigh the cost?

Bill Inman : Oh yeah. There's no question. It's going to be adopted whether people like it or not. And so that's just that's just a reality.

Meriyem : OK what is your feeling about the implementation of blockchain in AI.

Bill Inman : I feel it's necessary as a solution alternative to Big tech Centralized AI. We've already seen that. Facebook got in trouble for leveraging AI and information in previous elections. And we need alternatives to centralized information, centralized solutions, especially around AI, because we need to be able to piece together the solutions on our own without somebody else, other platforms dictating that, it's just a very powerful solution. We need decentralized as an alternative.

Meriyem : OK. When you think it's going to be common? What is your kind of prediction?

Bill Inman : Within five years. I mean, you're going to have a convergence of A.I with blockchain, with robot, more with, you know, automated robotics. So it's not just it's not just AI and blockchain. It's all emerging tech converging. And accelerating. And it's those use cases that are going to be exponential.

Meriyem : Thank you very much, it was really interesting.

Bill Inman : You're welcome, it was a pleasure. Do not hesitate to share your work afterwards if you are comfortable with it.

Meriyem : All right. Have a nice day

Bill Inman : You too.

Interview Hasen Kapasi

Meriyem : Hi Mr Kapasi, how are you?

Hasen Kapasi : Good, thank you very much.

Meriyem : Thank you for joining the call. I will present myself quickly. My name is Meriyem and I am a second year master student in Business Engineering, in Belgium. And I am finishing my master with a thesis about how blockchain can impact AI. How the trustworthy technology of blockchain can positively impact AI: exploratory research for technological and ethical aspect in healthcare. Could you introduce yourself, your relation with blockchain and AI as well as with healthcare?

Hasen Kapasi : Sure, I answered myself, Hasen Kapasi, I'm leading the PwC Europe blockchain practice and in blockchain we have immediately two areas, one is really on the crypto side of capital markets and the other one is completely blockchain implementation in industry that we categorize as enterprise blockchain meaning specifically your topic, for example. You know how we implement blockchain in various industries like Pharma, automotive manufacturing and so on. And that is basically the home base. So I'm expertising or I am on the enterprise blockchain side. So I'm really not an expert on the cryptocurrency side. I worked on that project, but that's not my specialization. So now I'm really focusing on the Enterprise blockchain side. And I have been working on this topic now more than three years. I have a digital background. So before, I was really working on the IoT and AI topics. I worked more than three or four years on that topic, really working on various topics and then really focusing now on the blockchain. But not only blockchain, but how can we bring the emerging technologies like IoT blockchain, AI all together. I have been driving on Europe as well as now on the global level, basically.

Meriyem : OK, that's interesting. And so about blockchain, how will you define the technology?

Hasen Kapasi : So basically, it's a distributed ledger. I do not want to bore you with the definition but it's a distributed ledger. It's a couple of characteristics. So I would start with the characteristics. There's a couple. It's a distributed ledger. It has the automation feature, the smart contracts. It's a cryptography event. And then last but not least, you know, what we have over there is also the combination of all of those. The key word over there is basically trust based. So what you're bringing is trust in the ecosystem using this technology. And that is why it is quite really well accepted in the industry.

Meriyem : OK. And besides, trust and decentralisation, what are the other benefits of blockchain?

Hasen Kapasi : There are many to name. So I think a couple of them. In terms of time, you're really chasing on it. You're automatizing the major processes in terms of advantageous. Another one, what you can do is removing the intermediaries. You're removing people and all kind of key bottlenecks in between. So that is one of the major benefits. I think one of the major benefit by people on using blockchain in the industry as a single source of truth. So blockchain is a piece of technology, but it's connecting multiple companies, which is not possible with any of the technologies. And I think that is one of

the key advantages. What we chase in the industry at the moment and which is another advantage is immutability. Nobody can change anything. I thought of a couple of key advantages we see in the industry. These are very generic. In health care specifically what you are really chasing are its advantages. You can see the complete trail of medicine. So that is not a kind of tangible advantage, but it is a qualitative advantage, I would say.

Meriyem : And talking about health care, I was writing in my literature review that people were more eager to use a public blockchain than a private. What do you think about that, especially for health care? Which one is better?

Hasen Kapasi : It depends. It's a difficult answer, but you know why I think is that you need to understand the reason why public blockchain is a public blockchain. It is basically, open source. It's being used for medicine tracing. So really to avoid counterfeiting. The second one is basically really using the data, connecting the huge data silos of the governments or any of the other institutes, research institutes. Here, for example, in Germany, there are so many other institutions. And ultimately why they are using Blockchain is really for collecting the data anonymously to get some results or insights out of it. For example, for cancer research, for gene therapy and so on and so on. And if you really want to use that data, it has to be a public blockchain so everybody can actually participate, first of all, and actually be trusted. If you say, OK, now that is a private blockchain own by ten companies, nobody is willing to share its data. That is why now there are two phases of it. One is really getting the data, collect data. And then also this trust part, because that is how you actually say, OK, this is a public platform where everybody can upload the data anonymously and we can use it for the insights. That's why people are really using and going towards Ethereum based platform like US to really develop the concepts for the gene therapy and so on. And in terms of private blockchain, I think, you have a kind of ecosystem developed by multiple companies and it's like a separate ecosystem.

Meriyem : And what about incentivizing the patients, if now they own their own data and they exchange their private data against tokens. How can it work? Is it possible to remove the power in the big companies' hands? How is it working and is it really possible?

Hasen Kapasi : I see there are two parts of your question. One is, can we use tokens? And the power of big companies. That is not clear to me. What do you mean by that?

Meriyem : In the articles I was reading, they were saying that if data are on blockchain, the little companies will also be able to access the data that normally they didn't have access to.

Hasen Kapasi : Exactly. So that's a great point. To answer your first question, Token, so rewarding the patients, the incentivising is really undermined at the moment in this auction topic, because at the moment, people do not understand. Why will they participate with you? It is one of the key question. And also going towards customer, why they care using your platform etc. And the answer to that is incentivising. I think that is the key topic which will be coming in the next couple of years. How do you develop the rewards or loyalty programs? And Tokenization is the answer to that. So, for example, if you have two phases, the first one is consent. First of all, if you're agreeing on sharing the data, you exactly know where your data is being used and who is, you know, using that. So you have

the transparency. So that is one of the benefits of Blockchain. Because sometimes we shared our private data with a website. You just click a small checkbox on the bottom of the website that "I agree", but you really do not know what is happening right over here. I've seen a platform which is being developed and they say "OK, we will be using the data for the next three months and then when the three months end you'll get a notification that we are deleting the data". That's transparency. And the second thing is once you agree you have some kind of rewards mechanisms behind it, you get tokens or something just to share the data for research. Another type of data is all the financial transaction data. So I think that's where they will be also praying to see how they can really agree upon that. They actually use tokens on the transactions and so on. For example, you pay via your credit card or something like all the digital banking started. So if you use now tokens, you'll get some more cashback tokens or something, so that's how it will work. Coming to your second question. So how small companies benefit? And as I mentioned in all this data, now, at the moment, big pharma companies leverage it just because they have the money so they can have access to some of the company's data and some of the data recorders from the big research companies because they have the money. And if they find something good out in the market, they're capable enough to buy those companies so they do not have any competitors. But now in the future, you can actually track starting from the patent's right of it, and there are multiple models coming out in the market where you see a data, what is insights coming out? And you can actually sell each piece of the insights. So I think that is where there is no monopoly in the market, you know, because it is all open source. And then you can actually anonymously see what's out in the market. So this is how the markets are. But nevertheless, you know, the patent business and all the patent medicines, I think that will stay.

Meriyem : OK. OK, and now to talk about AI. So, first how would you define AI?

Hasen Kapasi : So I'm actually not an expert in AI. But anyway, I can give you a try. AI is basically making sense out of the data. So I think I would say AI is basically what are you using today in your day to day life, like all the social media platforms at the moment, like Facebook and Instagram and Amazon. I think those are the great examples of the AI platforms. Nobody understands that there is a huge and tremendously smart AI actually algorithms running, because if you see some advertisements, popping up advertising in all the social media platforms, that is AI. So you know how you can relate that to industry. So, for example, if you actually are searching for any specific items or any requirements in business, that has to be a recommendation. For example, if any patient is looking online in an e-commerce Web site of any medicine platforms and he says, OK, I have this and this problem. And then it has to be a recommendation in terms of price and everything. So this is what I understand with the AI in a very limited language. Pharma has a lot of data and machine learning is really making sense of the data which human cannot read, comparing some out of the box data sets. You have some cancer research data, so you connect those data sets with the food habits. You connect those data with the lifestyle habits. You connect those data sets with the continent. How the weather is, how the human condition is, how they live and then making sense out of it, you see what are the symptoms, what are the triggers of that. If you go on the diagnosis side of it. So in the health sector we have the symptoms, diagnosis and then the solution, I think three main areas. And in all of these areas, AI machine learning plays a huge role. And so, as I mentioned in the symptoms, you connect those kind of data sets and diagnosis. You can connect multiple data sets and ok what was the trigger for those symptoms? And then diagnosis follows. What are the side

effects? What were the allergies, the conditions and so on. So, you know, bringing those three phases of this health care sector will bring tremendous insights. So I think this is where really the benefits will be coming on that side. And I hope that helps because I'm really not the AI expert.

Meriyem : No, no, that's perfect. But what are, according to you, the challenges that AI is currently facing in terms of ethical and technological issues?

Hasen Kapasi : So in terms of technology, I can give you a point. One of the biggest one is data. Everybody wants to have AI algorithm. One of the biggest challenges is getting that data right, because at the moment those algorithms need to have a specific data that they can understand. And at the moment, companies have different maturity. So if you're buying a company, any healthcare company or any of the company, they hold their own functions working and they have their own data silos at the moment and everybody has their own terminology. So if you really are looking at the healthcare sector, they have their own different language. And then the data have to be cleaned in those languages. And getting the data right is, I think, one of the biggest challenges. Because as I mentioned before, we need to compare those data sets. And that is at the moment, you know, one of the biggest challenges that we have. It has to be a common language or has to have a kind of a common ground or work on framework. If it's a cancer therapy, then what are the players in there and then those players try to have the same data language so that they can actually make sense out of the data set. At the moment, I think that is one of the biggest challenge. I think it's a matter of a couple of years and I think then it would be really out there. Ethically, so as I mentioned, how we use that data. So it needs transparency. And that is how you can connect with the blockchain, because if you're just here with AI, you need to have some trust on data you are sharing. So I think that's where I think blockchain play a major role in making it ethical.

Meriyem : OK, then my next question is about the data management and how we can use blockchain to facilitate the accessibility to data that are fed into the machine?

Hasen Kapasi : Yes, I partly answered your question. The answer is trust, right? So if a company says, OK, I have my algorithm, it provides you all the insights, that's fine. We can actually believe it's not futurist today, but why other companies would share the data with you? Because healthcare sector is a sector where data are goal. Whatever the researches they're doing, in terms of clinical trials or in terms of any of the medicine researches or any other stuff, nobody shares any data with you because that's their IP. And in that environment, if you say, OK, I want to have an AI algorithm, AI platform and you do not have that data, that's where blockchain will come into play. Blockchain will make sure that each and every part basically gets in line and everybody has the same transparency and trust on that system that we agreed upon. So, again, I would like to highlight here that blockchain is a team sport. So it's not like you want to implement a platform in your company and you implement it. That's not what the technology is for. It comes into play when there are multiple companies, multiple meanings, more than four. Not two or three, because you can actually manage with some other digital software. But when there are multiple companies, more than four, you know, where they say, OK, I do not know the fourth company, because I'm not directly relating to it but I need to share the data with them so that, we have transparency enough to get the insights. That's where Blockchain comes into play, because then blockchain ensures that whatever the data sharing is, it's

benefiting all the four companies, it's not just for one company and whatever is being shared. It's not being stolen or not tampered or not being misused for any other purpose, and are being used for the purpose which is defined by all of the four companies up front. And that is how it would really benefit.

Meriyem : And talking about transparency over data can blockchain also help to increase the transparency and the explainability of a decision that has been taken. Like if we trace every steps that the machine has been taken to arrive to a decision. Is it possible and how?

Hasen Kapasi : Yeah. So that's what I said in the definition. I would say that of the key features is time stamping. Blockchain can actually cover each of the times and each of the steps which happened during this process. So an AI based algorithm says OK it analyses this data, this data and based on this analysis this is the result you are getting. Blockchain can trace each of the step and you can see it and structure those processes. How you want to build the transparency in blockchain totally depends on how you develop the platform. So I think that is basically the architecture or architecture design of the platform.

Meriyem : But some people that I interviewed were saying that it was not possible to open the black box, where the decision of the machine is taken, that it was not possible to put a blockchain there and then to trace the decision.

Hasen Kapasi : Yeah, the reason is that there is a mix of funds because everybody has a different understanding, because the question you are posing is quite generic. If you select one specific process and say, look this is the process and this is an executive step, I want on that basis, I can tell if it's possible or not, because blockchain and AI are just a piece of technology. So it won't make sense until we give them a sense. In the case of Supply-Chain, in medicine counterfeiting. What does transparency in blockchain means so which chemical has been used, whatever providers? You know, how it has been made. Who has taken it from the manufacturer side? Which transport company is taking from point A to B. Where is it now? Who sold it to me? These are the points which you can see on the blockchain platform. So this is the transparency you get. But then as a consumer, you really do not care basically which company, chemical company made this. Which transport company brought from A to B, you really do not care. So as I mentioned, a blockchain helps with only more than four companies. So to answer your question, all those ones are possible in a way, how you structure the platforms, all comes to restructuring this platform and who see and what. That is the definition of transparency on blockchain. What is the value of the transparency is the most important question. OK, but then that's what you got the mixed answer, because everybody has a different perspective of understanding..

Meriyem : I was reading that, for example, if AI helps to make a diagnosis, for example, and that the doctors wants to know how the decision has been taken, then if all the steps have been registered on blockchain, it could help to trace back the decision. But it seems, according to another person I have interviewed, it seems complicated to do so because that means that maybe we have to put the A.I. on blockchain.

Hasen Kapasi : It's possible, I would say, because you need to understand the architect system. So where do you put blockchain? Blockchain is basically, you have two possibilities, on chain and off chain. What is off chain is basically you are hosting the

blockchain on a cloud solution. What you are storing only on the blockchain is just a hash of the data, kind of a signature of the data or any PDF file. In terms of that, that is a diagnostic coming out of that algorithm. And if you want to store that diagnostic, it will be stored on the blockchain as an event which you can review it so you can actually see it. For example, you know, Doctor actually wanted to understand this. It is a machine and do diagnostics. And Monday on that specific time and with the time stamping of that event, it would be stored on the blockchain and then, you can say, OK, that was all kind of a recommendation from the AI software. Doctor prescribed, from his experience, this one. So that would be like in the next five minutes, it is another event which is stored on the blockchain. So this is how you can actually store that information on blockchain but as I mentioned this is actually how you actually want the structure this platform.

Meriyem : OK, it makes sense. And at the beginning, you were giving one of the benefits of blockchain as a trust improvement means. And I was reading that the end users will not tend to trust an AI machine. How can blockchain helps increasing that trust in a decision taken by an A.I., according to you, if it can.

Hasen Kapasi : Yeah. So I can actually give an example. So what do you think AI is being used at the moment in the healthcare sector, in Germany, in Germany especially?

Meriyem : There are couples, for the breast cancer or for finding arrhythmia or cardiovascular disease to prevent a disease where AI is analysing different things and different symptoms for different aspects.

Hasen Kapasi : So, you know, at the moment I am not really much up to date yet, but I know breast cancer and the pancreas cancer that the two types of cancers where you know AI algorithm has already proved themselves. So I think IBM has done a great job, I think majorly from the US data. And if you're looking deeper into that kind of database, you know, there are multiple continents. So in US, the patient data is readily available, right? Patient data, meaning not the name and all of those things, but what was the age, you know, what was the blood group and all that stuff. In Europe, it's very difficult because of the GDPR rules. So you have only those data, which is consent from the patient. So if there is somebody suffering from the cancer and you've given them the consent, like, I'll sign for this and stuff, you have the data only. So, you know at the moment why they are facing this problem is because if you go to any specific company or any specific hospital or any specific institution requesting this research, and they come to you and say, OK, you know, I want your data, medical reports. And they really do not trust us because they really do not know how they're going to use it and they do not have any transparency. And that is why and I think that is a common culture in Europe, they are really hesitant to share the data. So I think that is one of the biggest challenges. But then if you have an app where you see, these are the purposes we are going to use your data for, this is not the institute which is going to use your data, this is not the topics for which we are going to use our data. It can be used for a specific timeframe for the next six months. And then you will get a notification when it gets deleted. Then you will see in your app you will be rewarded. Right, for the use of the data. Will you share the data or not?

Meriyem : Yeah, I mean, if it's protected.

Hasen Kapasi : Right. So you said yes. So this is exactly what you can do with the blockchain.

Meriyem : Yeah, and as we talked about traceability of the steps can blockchain also help AI in a way that a doctor will more be eager to trust a decision if he knows how this one was taken? It is all about the data?

Hasen Kapasi : Exactly, it's all about the data because, you know, the trust will control the system. But ultimately, the core of the system is data. So if that isn't in blockchain, you know, garbage in and garbage is not out and blockchain can help. Otherwise, the garbage stays in. So if you have a lot of data and a doctor needs to really have a systematic, organized and long term data. For example, we know we are doing a project for machine learning. It's not going to be implemented today. And you can start using it tomorrow. You're getting recommendations on everything. It's not like that. What companies are doing is really implementing the software in their systems with data for a year or two years or even five years, and after five years, you really get the fruitfulness of those platforms that now they've seen multiple scenarios, they've seen multiple instances, and they can really, increase the trust on that recommendations. You can actually see, for example, a couple of systems, I do not know which banks you are using it. For example, if you're in Germany, if you go on any insurance website, you have this AI chat bot. A fake user speaks with you quite nicely because insurance companies are the most advanced in this bot. Those chatbots are really trained. But, you know, if you go to any other industry, like automotive, those chatbots do not really help you. If you use any digital banks, if you go now, there is always a chatbot which is AI based. I am using myself a couple of banks, they're super high AI based chatbot where normally your questions are answered by them. You do not need to really call them. So I think that's not coming in a day or two. I have been using them from the start and I think initially they were really not helping. But I think now after three years, I think it answers all your questions, basically. And I think that is how you get the value and trust to opt out of that systems.

Meriyem : And also another question about the data. So, can blockchain help to increase the quantity of data that we are able to feed into the machine?

Hasen Kapasi : No, I think, as I mentioned, blockchain is just about trust and security, it doesn't matter how much data you are feeding into it.

Meriyem : And about the issues, I pointed out during my literature review some issues such as the discrimination and the unfair biases. And so the question related to this is can the bias and discrimination be reduced via the use of blockchain.

Hasen Kapasi : I need to understand the topic a little bit, but what do you mean by discrimination? I do not think blockchain can help there because blockchain is not a smart software, it's not an algorithm. It's really underlying technology, you know, which provides you some kind of immutable or a single source of truth along with the decentralization. That's a really the hard core, the decentralization of your data, what it is doing. So it really doesn't do any smart recommendations basically.

Meriyem : Yeah, I think there were more talking about the fact that if the data are more secure and that we can trust the data and that we collect data from different population,

from the developing countries or the African countries, then it can reduce the bias with really good quality data that we are going to feed into the machine.

Hasen Kapasi : Yeah, but I think that for sure. As I mentioned, that's it and quality.

Meriyem : And do you think about other applications of blockchain being useful for AI besides data or you think that's the most important parts?

Hasen Kapasi : For AI, yes, I think AI, if you go by industry to industry, there are many applications. For example, how you can use AI is really, connecting points. For example, if you are recommending some medicines to the patients. You run an AI based platform. And you said, OK, today you have a discount. So AI is basically those smart recommendations which you get.

Meriyem : It has been three years now that you're working at PwC as a blockchain specialist, right?

Hasen Kapasi : Yeah.

Meriyem : Have you seen an increase in the number of companies willing to integrate blockchain?

Hasen Kapasi : Tremendously. I mean, every year it's more than double in interest. So and how do we calculate those interests. With the project request we are getting, the proposals we are getting, as well as the project ideas we are getting from the client and the number of projects we are doing. So, you know, over the last three years it was more initially educating the client. So what is blockchain, the ideas and so on. Last year was more or less sort of project request coming from a lot of the use cases. How does this work? What are the type of blockchains,... And all those things. And this year is really how can we implement this along with different other technologies like AI analytics, IoT and so on, and how can we actually go to the market. So, as I mentioned, you have this transparency, you have AI and blockchain based platform. So what do you really want to take out of this? These are the maturity level of the projects we are getting. And also for that, you know why we're doing this or why companies are doing it. As I mentioned, they need to start now so they can reap the benefits in 2023 or 2025 because that's where they will be able to reap the benefits out of it. So the companies know this, you know, and especially in the pharma companies. I think the pharma is one of the largest industry in the AI and blockchain space where they realized the potential. So in health care, there are three areas. In terms of the health research. On the health research supply chain, topics like medicine counterfeiting, which is one of the biggest problem of the pharma side, as well as the IP right side.

Meriyem : And you already have some example, I mean, some companies which come to you asking for the use of blockchain with AI?

Hasen Kapasi : I'm actually working on the project at the moment. So at the moment I'm working with the pharma company, I would say five pharma companies, one of the top five, and they are implementing a blockchain based platform where we're connecting IoT, analytics AI, machine learning and blockchain.

Meriyem : It would have been a really good use case for my thesis.

Hasen Kapasi : Exactly. But I cannot provide you any more information. But that's why I mentioned you that this year, it increased. And I was actually very surprised to see those kind of projects coming from the pharma companies. They say, hey, we've done this and those companies are already bet on this. So, you know, it's not like you're talking about some research paper. They already filed patents in the US and Europe. So it's a patent now. This is not some consulting project anymore. It's really something very, very tangible. And it's coming from all the ways of, you know, pharma side from gene therapies, from clinical trial testing fraud, because pharma companies have one of the biggest business units of life science where they test all the food before it is being sold in the supermarket. So how can you ensure that the food, which Walmart sells is really coming from that specific company or to that if you are buying a bio product, how can you ensure that the apple you're eating is really bio? Because there are thousands of stakeholders in between. And that is being tested. So this is where the companies are getting their heads around. I'm pretty excited about this.

Meriyem : Yeah. And when you are using, for your use case of another use case, blockchain IoT and AI, the main common points between all of them is always data?

Hasen Kapasi : Exactly. So now you got that exactly right. So if you really want to track any product information, like aspirin, you're using it. if you want to say, OK, I want to know how my aspirin is coming tomorrow to me, who is producing it, that has to be a common language or common data point across that supply chain. This is a supply chain example. So, for example, for that product, considering aspirin, it's a physical product. It doesn't get any data and it has been in the SAP of a manufacturer. But that is not a digital identity of that specific package, which you are buying. So for that, you need a IoT. What we mean is dynamic QR code or anything which connects that digital product or physical product into a digital product. That's where, you know, you start your digital life. Then you need to think like, OK, first of all, you are transferring from physical to digital and then IoT based tracking. So you are tracking it now with IoT. You are automating some of the processes using blockchain and bringing the trust. Now you can believe that you have a data which you can trust. And you have a full single source of data which you can use for machine learning. Once you say, OK, I used a machine learning with this data, now I can make a smart recommendation. That's where the AI comes. So this is like a complete lifecycle of it and AI and advanced analytics. So what is the difference is, AI is really for the recommendations. You can actually use that for the strategies and so on.

Meriyem : What about interoperability?

Hasen Kapasi : It's a great question. Great question. Yeah, I think that is the question you know, most of the companies are not asking today. Definitely the leaders are asking, but.. So what happens if you just use one blockchain? It will end up like SAP. If ten companies are participating, the companies need to think about how the blockchain can be interoperable. It's easy to talk and connect and interoperate between this because, private blockchain, you can also do it for sure. It's the same. Public to public, Public to private, It's all the same. But I think public is more rich on that one. There are multiple solutions like Bullecourt or Chainlink. You know, they are already out there and there are standards out there. So I think it is already being solved. It's not a bottleneck at the moment anymore.

Meriyem : According to you, what are then the challenges you are facing, as a consultant, by integrating blockchain and AI?

Hasen Kapasi : So first and foremost awareness and education are issues. When we speak to any specific domain expert, they have their own expertise in that. And normally they do not understand the full picture. As I mentioned, blockchain is a team sport and you need to understand the complete endurance cycle. People just think about their specific business. And they do not really understand. And that is why consultants play a major role at the moment because we've been there as an orchestrator. We understand suppliers, we understand buyers, we understand the manufacturers. And then we say, OK, this is the full picture. I would say only 10 percent of the companies in the market see what is the value of it. Because normally, with blockchain, people think of cryptocurrency. There are so many myths about it, but nobody understands what is the real value it is bringing. The company I am working for at the moment for example, is really struggling to collect the data and getting the data right. You know, so that is one of the biggest problem. And it will be easy, but at the moment there is no solutions out there. It is not mature, but this will be very quickly solved. The third biggest problem is standardization, right? So everybody is doing what they wish. They are doing it, but there are no standards per industry. I think that is also coming.

Meriyem : OK, and no problems about the infrastructure of blockchain, there is not a lack of infrastructure?

Hasen Kapasi : Yeah, I would say infrastructure wise, it's now feasible. Most of the people think scalability is one of the biggest issue. But if you really want to develop it, I think that it is possible today. You heard the computational power, which is completely solved in the solutions like Hyperledger. But people do not understand it. So people have this matter on scalability like, okay, how can I scale to my big ten thousand people and so on. It's easily possible. There are companies like ConsenSys and there are many other ones which can do that. So I do not see this as a problem. It's not smooth like SAP a system. I would say, there are some ups and downs, but there is already a solution out there in the market because at the moment you need to have a stitch around that solution. So you have one piece of technology, you have another piece of technology, and you need to stitch those two technologies. So that is where the programming effort comes. It's not available on the shelf at the moment. And that's why people think, yeah, OK, this is the problem, but that's not the challenge. You can do it. But you need to have that vision and you need to have that understanding.

Meriyem : OK. It makes sense. I do not know if you have still time.

Hasen Kapasi : I have to jump into another meeting.

Meriyem : Right, thank you very much for your answers.

Hasen Kapasi : You welcome, have a nice day.

Meriyem : You too.

Interview Robert Miller

Meriyem : Hi Mr Miller, how are you?

Robert Miller : Good, thank you very much.

Meriyem : Thank you for joining the call. I will present myself quickly. My name is Meriyem and I am a second year master student in Business Engineering, in Belgium. And I am finishing my master with a thesis about how blockchain can impact AI. How the trustworthy technology of blockchain can positively impact AI: exploratory research for technological and ethical aspect in healthcare. Could you introduce yourself, your relation with blockchain and AI as well as with healthcare? How much time do we have for the call?

Robert Miller : I do have until 9:00 today, an hour from now, so, hope that's fine, and if you have follow questions, I'm happy to help too. I'm Robert Miller. I'm director of product management and strategy at ConsenSys health. Quick background, I started my career and algorithmic trading. So I wrote in operationalize algorithms in London, actually at a family office. I had done a bunch of work within healthcare before I interned at the Mayo Clinic and I ran some research papers in high school that got published. I wanted to be involved in the patient space because I see that there's a lot of potential there. And given my background in healthcare and sort of desire, general desire to make impact, I found myself at this blockchain health care start-up that was trying to give people better access to their health data. So I quit my job at the Algorithm Trading Fund that I was at and I started this start-up called MedicalChain. I did that for a year and then did another start-up and joined ConsenSys Health where I am now. I've been there for two years. I do a mix of like advisory and consulting work, product management and strategy. So I particularly work with some biotech and pharma companies on the consulting stuff and then product strategy, like setting roadmaps, help facilitate product discussions, try to decide what we do, at what time, what kind of customers we're aiming for and the problem we're solving. And outside of ConsenSys health, I write a lot, I think it's probably how you found me. I have a blog and I do a bunch of other stuff on the side like side projects, interact with decentralized finance or machine learning stuff of my own.

Meriyem : That's interesting. I will explain you what is the plan for the conversation. So I would like to talk especially about blockchain and I have four or five specific questions about that. Then I was thinking about going through the AI definition drawbacks, benefits, etc, how does it work. Then go to the third part about how the two can potentially work not together, but complement each other. And the last part is about the technological acceptance model. It is to see in the future the potential of these two together with specific questions. But you told me that you have one hour, right? So I'm going to go immediately the into the subject. So how would you define a blockchain?

Robert Miller : In a very technical description, it's a chain of blocks, you hash the data and put it in a block, include previous block's hash, and it's like a way of keeping a record of data that is time stamped over time. The unique innovation of cryptocurrency is why blockchain is relevant now, because it's been around for a couple of decades. It is a way of gaining consensus between multiple parties on a single state and timestamping that. It

was a very vague answer, but it depends on the context you are using it and the purpose I think.

Meriyem : And what are the principal drawbacks of blockchain's use today?

Robert Miller : It's slow and the development is bad. I do all this stuff on the side like actual coding, and it's just not good today compared to other types of developer tooling. You can't store that much data on a blockchain. You can't delete things, which means that you can't touch any sensitive personal information, which in health care basically all is data, right? And yeah, it's a rather inefficient way to do most things. But it's a great way to do certain very niche things that require a lot of trust.

Meriyem : And so besides trust is there other benefits that you want to clarify?

Robert Miller : I think the principal problem that is being solved is the one of trust. You might describe it in another way, like I can see how someone might describe it as a data sharing, for example, but I think even breaking down those kind of use cases, it comes down to trust and a neutral party between multiple different entities.

Meriyem : And what the system, compare to the current system that we know, such as the centralized system, add something?

Robert Miller : Yeah, it adds a neutral infrastructure, no single party controls, and that's useful in a number of different contexts. For AI in particular, it might help orchestrate the training of an AI, trigger certain actions at certain times, maybe decide parameters in which an AI can output a prediction. Maybe you need to pay or record an audit log of certain actions. And I think this ability to orchestrate things in a way that no single party control is very useful generally and specifically within AI.

Meriyem : Would you have maybe an example to illustrate the use of blockchain within AI as you just have said?

Robert Miller : So do you know very much about federated learning? In normal machine learning, you are taking a bunch of data from a bunch of different parties and you're centralizing it into one database and federated learning instead keeps data at the edge and it brings algorithms to the data. So what that means is you can have a network of different parties that are collaboratively training an algorithm. They train the algorithm on their local devices. Like your smartphone works for Siri and predictions of words that you're typing. So you'll have data locally on your phone, your training algorithm on it, and only the algorithm will get shared with other parties and Google or Apple or some central party will take all the algorithms from all of our smartphones and put them together and they're like a meta algorithm or a global algorithm. In their words that takes all the incremental improvements from my smartphone, someone else's, and mashes them into one to make much better improvements than us individually. And this is a way in which you can train an algorithm in multiple parties, but without any individual party revealing their underlying data. Where those things with blockchain, and I wrote about this in my article, is providing a way to orchestrate this process that no single party controls. So today, Siri actually works in this process that I'm talking about with Federated Learning where like you train the Siri algorithm on your phone, but all of that is controlled by Apple.

And you have to trust that Apple is not doing anything nefarious. But you could stand up and consensyshealth is creating better networks that no single party controls. Instead, the network collectively decides what kind of algorithm runs on the Federated Learning Network.

Meriyem : And is that related with the fact that I read in some articles that blockchain can help to make a joint decision like between several algorithms then?

Robert Miller : Yes. Also, in the context of health care, I think it's very interesting to take hashes of the data and putting it on a blockchain. Where I focus in biotech or pharma there is a surprisingly big problem of people tampering their data and not knowing whether, someone has tampered with it or changed it. Last year, Novartis was caught actually tampering some of their early data for two-million-dollar gene therapy that will cure blindness. They just edited and edited a bunch of data. So there's some conversations going on with pharma companies of using a blockchain to provide like a trusted base ensuring no one is tampering data, which, then if you're using that with AI it can help you to ensure that the AI predictions are correct and it has integrity because the data that it's trained on, has integrity. The other way to see this problem, I think, is if you do not have all of the data hashed and put on a blockchain to begin with, which is most data, then you need some other mechanisms to tell what the integrity of your information is or how much confidence a person has in it. And how NumerAI tackles this is by asking members to stake money on their data sets and so if you think you have like a very high quality electronic health record or a bunch of data, you can imagine a marketplace of information to be used in algorithms and each provider of data is staking a bunch of money, just setting it aside and saying this is really high quality. So it makes you have good predictions. And I feel so confident in this. I'm putting at stake one hundred thousand dollars on it or something like that. And the amount of money that someone is willing to set aside is a signal of their confidence. You have a sense of how confident people are in the quality of their data.

Meriyem : OK, and do you have other ideas about how to make the two technology merge even in the future or you already tackled the most used cases?

Robert Miller : Yeah, this morning I was just reading like a nice coincidence, I was just reading this article on blockchain based machinery marketplaces. The idea is basically to use blockchain as a way to incentivize people to provide data to machine Learning algorithm and then also as a way to create marketplaces for these algorithms.

Meriyem : And about incentivizing the people. I mean, it was one of my questions. Can we give the data into patients' hands, for example, if we use a blockchain to provide more data and then to train machine learning, like in a better way?

Robert Miller : There's a lot of people trying with like traditional technology to do something like a blockchain. People just do not have the incentive to share health records today. And different health records speak different languages. Blockchain won't solve that necessarily. But like I was describing before, they may provide some context in which people can make the data useful. Like in federated learning networks or in a blockchain based machine learning marketplaces So it won't give people necessarily control or

ownership over their information. I do not think, but it will give them new ways to use in AI and related systems.

Meriyem : And if we talk about AI to begin with that part, how would you define AI?

Robert Miller : It's a series of algorithms that are used to make useful predictions about data.

Meriyem : What are the current challenges that AI is facing ethically or technologically?

Robert Miller : I think there's basically one really dominant model for how to make money and that's advertising. And I do not think that this incentive aligned with the users. And you can see sort of the problems that exist on social media today. So when you use Twitter or YouTube or Facebook, they want more clicking on more links, staying on the websites longer, etc. And the way to do that is by giving you more and more extreme content. This content that you read, which usually means like within your narrow parameters of your political beliefs or your thinking generally, I think there's an argument to be made that this is pushing people towards more and more extremes and polarization generally and like destroying their attention. I do not know about you. So this is really derivative of the fact that, AI business model today for big tech companies is advertising. And if we found a different business model for AI that could provide the same level of returns at the same scale, I think that would solve those problems. But nobody has really figured this out yet. It's a big problem. The second, we do not have the right relationship between users and algorithm owners or trainers and I think if we could develop systems that treated people more like stakeholders, where I'm providing data to the system in return, I'm getting some sort of value, my contributions are being recognized as valuable and treated like a true stakeholder. The way that it works today, algorithm trainers like Google, Amazon, etc, they do everything possible to let you know that you're there to try and keep you from knowing that your data is being used to train an algorithm. But it's pretty cool that my information is being used at Amazon to generate all these recommendations. And Google was using my captcha in order to train self-driving cars. And I think if you reframe this relationship, you treated people as true stakeholders, then they would want to contribute more and maybe they would contribute to higher quality data. No one has figured out the right way to frame this relationship and I guess it's like the socio economic context in which our lives are created. And I think that's a big problem, especially if you think that algorithms and the data economy are going to grow much larger than if people are not treated as true stakeholders. They're not going to capture any of the value that is created by this economy. And then the most training of algorithms is all done in centralized context. You send all of your data to Google, they put some training for algorithm on top of it. In health care, information is super sensitive. And we've seen what happens when you send a ton of health data to Google, there's a huge amount of uproar. People do not want Google to have their information. And so centralizing data is not a viable strategy in the context of healthcare. We need ways to train algorithms that keep data private at the edge or at least within the confines of a hospital patients trust. It is only through decentralizing it can happen.

Meriyem : But talking about data, one of the question was how blockchain can help to facilitate the accessibility to data and then to use them to train AI?

Robert Miller : Certainly you can use a blockchain to record data permission. Your AI could click on a couple of buttons and then you're setting boundaries on how we want our data to be used. And there could be an immutable record of that that could then be referred to as like an audit log and that every time someone accesses your information and uses it for some purpose, you could record that within the blockchain to give people the ability to go back and look and say, here's who had access to my data, at what time, for what purpose. And I think that would go a long way to facilitating trust. And ultimately, more data sharing and usage.

Meriyem : OK. And how thanks to blockchain transparency and traceability of data used for AI can be met?

Robert Miller : I would return to the example I just gave you, of an audit log of actions that were taken, with data that are posted on blockchain and that somebody can go back and look at and see, you know, here is what I did, it has been used for what context and by who. That will let people have a lot more insights into what their information was being used for and a lot more trust in sharing the data.

Meriyem : OK. And according to some studies, I was reading that there was a lack of trust from doctors and patients towards an AI machine? Can it help to increase that trust from users and from patients or doctors towards any machine?

Robert Miller : Yes, it's a complex problem, but I think it helps and in some contexts, I mean, a big problem with AI is figuring out how it came to its conclusion. And there are all sorts of people right now that are training AI that will identify lung cancer or make some predictions or this or that. But oftentimes these things are just like thrown out into the world and you have no insights into how they came to their conclusions. And there is no way to reproduce them, which is a central principle of the scientific method, is the reproducibility of findings. But you just can't do that with most AI. And I think it is interesting to think about how a blockchain can help solving that part of the problem of providing an audit log of the particular actions that were taken and the data sets that were referred to such that a third party could go back, take the same actions with the same sets of data and come to, in the same code, to the same conclusion, the same algorithm, and to be able to reproduce what was made with a lot more integrity and trust. And that's not possible today. So I think that would add general trust in addition to training and training data that has more integrity, that has been posted to a blockchain as well, I think would be useful.

Meriyem : Yeah, and if the steps of a decision taken by AI is registered on blockchain, for example, if a machine says that I have a cancer, can the steps for this decision be also registered? And can it help doctors to know the machine took the decision?

Robert Miller : This is unfortunately a problem that blockchain cannot solve.

Meriyem : OK, but it can improve trust in general. Therefore, it can increase the research and development done through AI and for AI if you have more data to train the machine?

Robert Miller : Yes

Meriyem : Can it help with discrimination and unfair biases?

Robert Miller : Yeah, in a couple of ways. The first way is in providing a better sense of what data were used to train. You see all these headlines of people doing things with algorithms, but it's usually just like a bunch of white people in America that their data has been used to train. And in particular, this is really bad genomics where we have great coverage of Western Europe and America and that's like all of our genomic data, but no one else in the world. But anyway, so having a better sense of what data sources we're used can help you decide whether the data is really representative of the population that an algorithm is being used for. And then in this future state where you have blockchain networks that are training algorithms and facilitating the training of algorithms, these are neutral and open networks that aren't going to discriminate against any person.

Meriyem : And about transparency and explainability, we already talked about that but would you have something to add?

Robert Miller : Being able to reproduce steps. But some algorithms are just inherently black boxes. We do not really understand very well why they come to their conclusions. And a blockchain won't help with that question.

Meriyem : And about the legal aspects and governance, can it help?

Robert Miller : I mean, it certainly would help if you had a record of other folks, but you've asked for data and their consents. I think that's helpful. That is the kind of thing that people have talked about for a long time, actually. But ever since I've been in the blockchain space, people have been talking about this and I've never seen it actually done in real life. So theoretically, it's helpful. But yeah, it's like always that thing that's on the horizon, people keep on talking about. But yeah, the governance is interesting because it will allow groups of people to control algorithms and to make decisions about the algorithms in a way that's not possible today. Like I was describing you earlier, Federated Learning Networks. So I really like this idea of collectively owned, collectively governed algorithms.

Meriyem : But how will it be possible with blockchain?

Robert Miller : You know, in a federated learning network where you're training algorithms on people's devices, you can have a blockchain, decide what is trained and when and actually execute the different steps of machine learning that are taken, like run this file on this data at this time. And individual artist could mark the data that they are interested in contributing or not. And you could have the algorithm and its execution governed by what the members of the network collectively say. The way that the software we're building works is you might have a network of five hospitals in our Federated Learning Network and only if all five say that they want to have an algorithm trained on their data in this Federated Learning Network will anything ever be run on their local infrastructure. And if one hospital says no, they'll either opt out or the algorithm won't run at all. And so in this way you can have the network decide what is run instead of one party decides if an algorithm runs or not.

Meriyem : Ok, it's clear. And what about the developing countries, it can be difficult maybe

regarding the infrastructure or maybe it's easier in the developing countries, what do you think about that?

Robert Miller : I think certainly there are less data privacy protections in developing countries. So, that might be helpful to some people to go to places where they do not have to play by the same rules. I mean, personally, I can tell you that when I was at medicalChain, we had somebody that tell us that they could get us access to over 10 million health records in China if we were willing to come and like sign a business deal with them. So I have first-hand experience with this and I do not know, we never face that down and it sounded like kind of sketchy. And the problem I think is that in lower income countries, you won't have the same kind of technical talent that you will in other places like the blockchain world and the machine learning world is remarkably concentrated on three or four places for machine learning It's basically San Francisco, a little bit of London and then a little bit of China as well. I do not know where in China. For the blockchain world it is San Francisco, New York, a little bit of London and Singapore, I think, basically. And you would be hard pressed to find the type of people that you would need lower income countries.

Meriyem : What about privacy and the cybersecurity?

Robert Miller : I'll come back to the audit log again. Being able to show people how their data has been used and when. I think that is the only real way a blockchain can contribute to that.

Meriyem : How can blockchain help with the decentralized computing power use for AI?

Robert Miller : I think it's there's a pretty good analogy to be made between, like proof of work networks and all the computing power that's being done there and training AI algorithms. And then when it's not profitable to do that, they will instead be rented out to people that want to train algorithms instead. so there's like huge amounts of computing power that are just sitting on the sideline. They'll swap between training algorithms for mining Ethereum or other crypto currencies.

Meriyem : And what are the issues you think about the fact of using blockchain for AI?

Robert Miller : I think the principal problem is that it's very difficult to do things on a blockchain if what you're acting on is not native to a blockchain. That makes sense, so it's already pretty hard to work with Ethereum or a cryptocurrency or something on a blockchain. It's much more difficult to work with things that are off chain, which is inherently all data, basically, and doing so you need like intermediaries that can take data that are off chain and put them on chain and then maybe those are trusted third parties. So it introduces a lot of problems just working with things that are off chain using a blockchain. And that's, I think, the single largest problem in that space. In general, the developer tooling is just not very good. I know I said that at the beginning, but I'll stress it again. It's just hard to work with the stuff. I had a bug and some of the code that I was writing and it turned out that it wasn't actually a problem with anything that I wrote. All my code was completely right and it had to do with the other software that I was using. That makes sense and it took six weeks to figure this out, probably 50 hours to find out what the problem is, not me. And it was actually the software I was using. This is

incredibly frustrating. And more developers are needed too, I think that's the problem. And then a lot of this stuff, people do not really know how to make money out of it. Like the business model for a lot of this is very uncertain and unsustainable. And so there's a need for, like, smart business people or maybe folks like you that can figure out how to turn these things from ideas into sustainable ventures over time.

Meriyem : OK. And we know that blockchain is kind of safe, but I've heard about the 51% attacks. So now if something bad happened on blockchain, it's also a problem for machine learning?

Robert Miller : You were technically right, but I think that's overblown a lot of the times. At least with public blockchain it is not a problem, in small private networks, it is.

Meriyem : And which type of blockchain will you principally use in health care as we are using sensitive data?

Robert Miller : I am controversial and I prefer public blockchain but this is not a popular opinion. Most people say private.

Meriyem : Yeah, but I'm interested by hearing your opinion then if you say public blockchain is better.

Robert Miller : Public blockchains are more secure and they have like a very long track record to them. So there are billions of dollars on Ethereum and there has been there for many years. So I know that Ethereum is not going anywhere and no single party owns it or controls it. So this is very useful for a lot of things. There are things that I wrote on the Bitcoin blockchain in 2012 that are still there, which is cool, and there will always be there. And you know in the context of health care, you're not going to be putting sensitive information on chain, whether it's private or public, it doesn't really matter. So if the information is going to be putting on a blockchain, it's just like a hash of data or something. And there's no real reason to not put it on a public blockchain. I guess the real reason to do it would be that enterprises are not comfortable working with public blockchain and they prefer private. But I think this is silly.

Meriyem : And what about speed? Because for now, blockchain is kind of slow. And AI is quick. But if Blockchain is slow, can it be a problem or not?

Robert Miller : This is true, it can be a problem. But the kind of things that you would be using a blockchain for with AI, I do not know if you necessarily need a lot of transactions. If you're using a blockchain to help train an AI, it's probably to record what you're doing, what data you're accessing and when. And it is like a single transaction for one training around. Maybe in the next round of training is another transaction and then you record the accuracy of each round. Ethereum can take 12 transactions for a second. Something like that. And what I just laid out wouldn't be more than 12 transactions for a second. I think it would probably be like one or two max or something like that, maybe less. And the other thing that people always talk about is the cost of using a public blockchain. And this is also true but having worked with big enterprises, it takes a lot of money to stand up a private cloud and then run a node in it and have somebody watching the infrastructure to license for all the software that's involved in it. There's concrete costs

associated with that as well. And I tend to think that the cost of using a public blockchain will be less than the cost of running your own. So, yeah, I do not think speed will be a problem and I'm not very worried about cost either.

Meriyem : So I think that we talked about the issues that they can encounter. To finish I am using, as I said, the technological acceptance model. So it answers basically the perceived usefulness, the perceived ease of use, the attitude toward using it, the behavioural intention to use and the actual system used. So, would the integration of two systems can enhance the AI and users' jobs performance?

Robert Miller : Yeah. Doctors and patients would benefit at the end. But the first sort of users who would benefit from it are like informatics', people who work with health data and our dedicated staff to that purpose within our hospital today. Those are the people that benefit immediately. And then down the line, a couple of years later, with more adoption, patients and physicians will benefit more.

Meriyem : And would it be easy to use and to implement?

Robert Miller : No.

Meriyem : Do you think that blockchain use in AI is currently understandable and clear?

Robert Miller : Read my blog post and then you can tell me what you think. But yes, it is.

Meriyem : And do you think that improving Blockchain literacy to people will take time before being able to use them together?

Robert Miller : Yes, definitely.

Meriyem : Will the benefits outweigh the costs?

Robert Miller : Yes

Meriyem : And what is your feeling, your impression about the implementation of these two together?

Robert Miller : I think it is immediately useful and in the more distant future, it will offer the possibility of creating algorithms and technological services that are totally different and have a better relationship with users than today.

Meriyem : OK, and what would be your attitude towards this? Would you go for it, for the implementation of these two?

Robert Miller : Yes, It's my job. So, absolutely

Meriyem : And so do you think as well that in the future they have a big potential to end up together?

Robert Miller : Yes.

Meriyem : I tried to do it quickly and I won't keep you any longer because you have to leave in five minutes. Thank you very much and thank you for your help, and if I have some questions that remain can I send it to you via LinkedIn, like to clarify something?

Robert Miller : Yes, you're more than welcome. I'll put my email. But you might get a quicker response on my email. Happy to answer questions if you have any. Good luck on the thesis and everything. I think the best thing that I would comment on if it didn't get across is, I think the real potential for blockchain and A.I. lies in its ability to create technology services that have a better relationship with users and are organized in a different way, where maybe users have more choice of the algorithms that they're using and even have ownership over their algorithm, people are getting paid for their data, maybe there's more open marketplaces. And people's privacy is more respected, too. This idea of incentivizing people, I think it's very compelling one to me. And that's where my core interest lies in the future. So if they didn't get across, I wanted to stick that in it before the end.

Meriyem : We still have four minutes, if you want to elaborate on this, I mean, it's more than welcome.

Robert Miller : Yeah, this consortium of big pharma companies, they're collaboratively training an algorithm together. And they all have a bunch of data on drugs called preclinical data. It's data on compounds that exist before they go into any humans, and that sort of gives you a better sense of how safe they might be or what their effects are. And every time a company has this and there even been some studies of using AI for this problem, but to date, there hasn't been any collaboration between pharma companies. The European Union, God bless you all, created this project and funded the collaboration of a bunch of big pharma companies together where they would take all their data and collaboratively train an algorithm. But I work with a bunch of these folks and some of the biggest parties were deciding whether they were going to participate or not and ultimately declined because they felt like them participating would give more benefits to their competitors and they would benefit from working with their competitors. There's this problem that you need to give parties outsized benefits from making outsized contributions and everyone thinks that they have the highest quality data on this and that, and you might be able to solve this for the blockchain by providing an incentive mechanism whereby you contribute to more data or higher quality data or you improve algorithm the most and you get paid more. Maybe you own more of the resulting algorithm or something like this. The incentive mechanism is not clear, but like the prospect of using an incentive mechanism to incentivize more collaboration, it is really interesting. And that's like an enterprise health care example where we're working through today. More broadly, I think you can generalize this to any types of algorithms like the content recommendation algorithms that you use on social media and think about using incentives to attract more users and their data in order to create better algorithms or creating like open competition between algorithms where users can choose what they're using, get paid to contribute to two different algorithms. And that would totally flip the model on its head. Instead of a user searching for a product, it would be products competing for users and users getting rewarded for it. So, yeah, that's just like some thoughts off the top of my head about the subject. And maybe that's the problem in space.

Meriyem : It's interesting. Thank you very much for your time and your insights.

Robert Miller : No problem, it was a pleasure. Good luck with your thesis.

Meriyem : Thank you very much. Have a nice day.

Robert Miller : You too, bye.

Interview Natalia Monteiro

Meriyem : Good morning, how are you?

Natalia Monteiro : Good morning, I am good and you?

Meriyem : I am good. Thank you for joining the call. First of all, do I have your consent to register the call for using it in my master thesis and transcribe it?

Natalia Monteiro : Yes, for sure

Meriyem : Thank you. I will present myself quickly. My name is Meriyem and I am a second year master student in Business Engineering, in Belgium. And I am finishing my master with a thesis about how blockchain can impact AI. How the trustworthy technology of blockchain can positively impact AI: exploratory research for technological and ethical aspect in healthcare. Could you introduce yourself, your relation with blockchain and AI as well as with healthcare?

Natalia Monteiro : Yes. All right, so my background is in business, I've worked and studied the topic of business, sales, marketing, and lately I was working in a pharmaceutical company in the clinical research department. So that's when I was doing my MBA. I was looking into areas where blockchain as a service could be used, and I applied this to the clinical trial setting. So when the clinical trial setting, I was looking for areas where it could improve the system. And there are several ways. So I've done some explorations there. There is a lot of potential because of the way blockchain is set up. You know, it's really the basics of blockchain that increases traceability, increases trust, increases decentralization of data, and this again increases trust. And that's a very good topic for pharmaceuticals. And right now, I'm working for a start-up that is developing on this topic. It's a patient data that can be sent to third parties, in this case pharmaceuticals, in a completely anonymized way. And patients, they know exactly who is utilizing the data. So the data can be sent forward via the blockchain. And this access can be also taken away any time they change their mind and they are also rewarded for their efforts. So this is one of the applications of what I have been studying. My connection with A.I. and this was that at the same time, I'm working in a company that works with A.I. Solutions for insurance companies. So it's how large amount of data can actually help you predict the future and live through this experience. I've also seen how this can be applied for health care and AI and bloc chain because once you collect the data from the patients, you can better run clinical trials and you can do meta studies even before you start your studies by deciding better location where you're going to run your clinical studies and also the likelihood of success of a clinical study can be also forecasted by an AI model. So just in short, just to give you a brief understanding of my connection with AI and blockchain.

Meriyem : Okay, perfect. Thank you very much. I would just quickly explain how the plan of call. So first of all, I wanted to talk about blockchain. So basically how it works, the definitions like the drawbacks and benefits of it, how it transaction's is cryptographically signed etc, then go to AI to see what are their issues and a definition as well, the challenges, etc. And then I have a part about how the two can merge with topics such as data management, trust improvement, discrimination and biases, explicability, transparency, etc. And then I'm using the term model. I do not know if you heard about it, but it's the

technology acceptance model. It is just to see the potential of these two together, like in the future. So basically, that's the plan of the presentation. So maybe we can begin with blockchain. How would you define blockchain?

Natalia Monteiro : To me, Blockchain is a platform that very similar to the Internet, has brought opportunities that are clearly not tapped on at the moment. So I think it's actually Internet 4.0. It's an evolution of what we have seen. And I see this is not implemented further because the industry is actually too busy trying to explain how it works. So when we first got an email, everybody was so excited. They are using it because it makes sense. So we were not worried about how it works, we were more worried about what can we do with it? And right now, there is a very good use case for blockchain, which in my opinion, is the crypto. So crypto is both good and bad and I believe in a blockchain as a service. So blockchain is a platform that allow actions that have been used in an unsecured way to be done now in a more secured, decentralized way without intermediates. And when we look at the example of the crypto, I see this is the finance use case that has worked and it's proven itself. So without banks, without central banks, individuals, they can exchange funds and it's all tracked on the blockchain. So transactions are tracked. It's completely decentralized. It's completely globalized anywhere in the world. Participants can be part of the blockchain and there is no need for intermediates. So I see this is like the perfect use case. Now, there is a need for an extension of the utilization and then we come to other discussions. Is this the public blockchain, public or private? When we look at the clinical trials or the health care in general, the benefit of the blockchain is trust. And why do we need trust? Because there is mistrust in the system and patients do not trust pharmaceuticals because there is an interest in the pharmaceuticals of sell more drugs. Government do not trust pharmaceuticals because they are paying for those drugs or for those treatments. So everybody has their own interest in this. Once you use a decentralized system where everybody both feeds and can get information out of it, that's when you are going to get the most benefit out of it. So I believe the blockchain is actually shaking a lot the traditional systems, and that's why the implementation is taking a little bit longer. So Internet could just happen parallel to it, but blockchain is actually shaking it. So the moment that we need on the same table and a blockchain that is public and permissioned where one of the parts is the government, the other part is pharmaceuticals and also patients' associations representing them, it's where you are going to make the most out of the information or the exchange because the blockchain does not care information, but it allows a free exchange of information. I think that's the powerful part of it.

Meriyem : What do you mean about exchange free information?

Natalia Monteiro : What I mean is, for instance, a patient provides information to a clinical study, right? So he goes to a research institute and he provides his information. So he agrees to that and he provides the information. This data can then be used further. And we do not know how many times further. So what I believe is that the person who collects that information is now more powerful because he has this information. But it's not benefiting the whole society, because now this information is locked in a silo. It's locked in that research institute. The information could be via AI research via the blockchain this information could then be much better used and I will give you an example. So if a patient could be, the data that has been collected could qualify that patient to be part of another study. And sometimes, especially for rare diseases, it's very hard to find a new patient. So

if it's very difficult to find and this information is already recorded somewhere, it would be possible to actually identify that patient and invite that patient to take part in another study. But because of the centralisation of the of the system right now, this data is never available to another research institute. So that's I find that it could be much better used in the future.

Meriyem : So again, how to improve the research and development, for example, for diseases which are not known?

Natalia Monteiro : Yes, and not only this. It also helps to understand concomitant diseases. So another example is, for instance, this person is rejected for a certain study because they realize the person after has joined the study and they figure out the person has a heart condition. Now, this person could be rejected for a certain study, but this person has already agreed to participate and it could be useful for a similar study somewhere else where someone is actually studying what is the effect of a certain drug or a certain molecule in patients with heart conditions. So this is just a very simple example, but it's a lot of data points that have been missing right now.

Meriyem : Yeah. OK. And you were also talking about the fact we have to choose also between private and public blockchain. Which one do you think is better to use in health care, according to you?

Natalia Monteiro : Well, my opinion is, is that it needs to be private, but it needs to be with enough participants. So actually, what we have seen is that a lot of consortium have been gathered and three or four blockchains have been created. The way I see it is that they're running parallel until one of them proves to be superior than other. It's a little bit similar to Yahoo! Search and Google search and Bing search, for instance. All of those, they are private, they run parallel. And consumers, they have their preference to which one they use. And I think the way it's evolving right now is that for health care, there are three or four running parallel. It could be that one proves to be superior at the end, but it could be that two or three are at the end with a lot of participants, but with specific uses for them. So supply chain is definitely one of the areas where they decided to work. So as an example, it could be that in a couple of years, they become the blockchain for Supply chain. So that's more or less how I see it evolving. But it's as you said, there is very little literature on it yet. And it's a 10-year-old industry, which seems a long time. But on the other hand, considering how revolutionary it is, I think it's quite young yet.

Meriyem : Yeah, sure. And what are the drawbacks of blockchain, according to you?

Natalia Monteiro : I think the drawbacks are, if you look at the characteristics of blockchain, they are both positive and negative, depending on the point of view you have. And I think that's quite an interesting point, because if we go one by one, so it provides a greater transparency. In my example, for instance, the patient, when he is a part of a study, he knows exactly which data he is sharing thanks to the smart contract. So instead of taking another lab exam, he says, no, I've already taken this last week with my GP and the data is in my electronic health records. All I need to do is to allow you to see my results. So this is not even simpler, but it also saves money for the clinical trial. So he allows it via a smart contract. So now a third party is allowed to see, it provides greater transparency. Right. For the patient, he knows exactly who owns the data. He owns the data, but he

knows exactly who has access to the data because he authorizes the person. This is a greater transparency but not everybody is a big fan of it. Because the data is used with different uses and not every country has higher standards, so that's one of the hindering parts, not that I find it's hindering, but I just think that that's one of the reasons. Another one is, for instance, speed of transactions. This makes everything much faster and traceable. What would be the need for auditors? If everything is actually locked in, of course, auditors and auditing companies do not have an interest for this, they will have to redefine themselves. And with models in A.I., for instance, you can just see if something hasn't been done properly. An example I can give you again, from the clinical trials I've looked at, it's the protocol. Once you start to study, you need to prove that when you were researching a certain drug, you were researching for X use. If in the middle of your study you realize, well, actually this drug has the Y side effect and this Y side effect is a quite positive one. Why do not we try to market this drug for Y instead of X? And that's what the protocol at the beginning of the study is meant for. It's actually to assure authorities that you are not changing your study as it pleases the pharmaceutical company. So if that would be the case, you would have to go back and say, now we need another study to prove that Y is a good application for it. And then once you've got the drug, what happened is that you need governments to check the protocol and you need auditing firms checking this protocol, if that would be on blockchain, you can imagine the amount of, less administration that is necessary. Also for those agencies, FDA will have much less trouble because all they need to do is to send a smart contract and the FDA sees our files as they are found through the smart contract. You can check everything when the first call, when the first protocol adjustment has been sent and so on. So actually, the speed and efficiency is incredible. But you still see parties involved that have very little interest for this to be in place.

Meriyem : And do you think about other drawbacks?

Natalia Monteiro : Well, I mean, the major one is we still need to rely on the cloud solution on the background because the blockchain is not meant to store data so there will be a lot of clouds and we have national governance where the servers need to be in a certain country, the cloud needs to be in certain country. So this is all valid. We have different regulations and so on. So I do not think it's a drawback per se, but I think it's a risk. So what happens is that we need cloud security because we need to protect this information. Again, on another point, you know, that's something that I have discussed for instance, is that a lot of countries, they're trying to do this electronic health records and centralize everything. And there are suffering. That's not happening because people are afraid. What if someone else gets a hold of my data? And what I think it's also that blockchain provides the solution in the sense that we do not need to collect the data together. So an example is, imagine that someone has a heart condition and has a mental condition. So perhaps this person does not want the employer to find out that there is a mental condition, find out that there is a mental condition, depression. I do not know exactly, but these two data points, they do not need to be in the same health record. So the mental hospital, the mental institute, can collect the data of that patient and keep it in the cloud at the same time, the heart condition is kept on that cloud. And when he shares, he just shares the minimum required information. I think that this integration of decentralized silos could also be a great use for it. So, again, I think I've just mentioned a drawback that can be also a positive use. But I think the drawback is the reliance on data repository. So those need to be really,

really secure and allow the users to feel secure as well, because that will help adoption and also sustainability of the system and over a long period of time.

Meriyem : Yeah. And you were also talking about the fact that at the beginning, if I remember correctly, the patients, for example, may be able to own his own data. How is it possible and can it help to increase the rights of the person of the patients, over his data?

Natalia Monteiro : Yes, so actually with, Electronic health records, that's the idea of owning completely your data, right? So if you look at the example of Estonia, all their health records are collected by the government and they also have high adoption of blockchain to share this data. So it's actually a fantastic use case. But their servers are based, they have a backup server in Luxembourg, but they are very small country. Now, if you would just imagine the same for US, where are you going to put their servers? You know, where are you going to do a backup of their cloud or create a second cloud? Cloud is a fantastic technology, but it's costly. So that's a little bit of an issue. But you ask me about having full ownership of the data. So in Estonia, the patients, they do have full ownership of their data in the sense that once they visit a new doctor, it's not granted the access to that doctor. So their doctor is not automatically seeing everything about that patient. If they go to a new doctor, the doctor will say, I need blood samples, I need a history, of course, concomitant diseases and so on, so. There is a smart contract with everything that is needed, so the patient receives that and says like, yes, OK, it's fine, I'm willing to share this data with this doctor, and that's when they share their data with their doctor. At the same time, if they want to see their own data, they can, because I do not know how the system is in Belgium, but here in Switzerland, for instance, the patient actually only needs to request and it may take forever to just obtain the copy of their own data records in a hospital, for instance. And I think that's what is a game changer, because it will allow them much quicker to, even for themselves, have access to that and for the overall health system. You know, you just imagine how many people, just because the doctors do not talk to each other, especially in the elderly, they do unnecessary tests because they are they're taken care of by different specialists. They right now do not have this free flow of information. And that's something that Estonia has put into place. So if someone attends three or four doctors in a week and those doctors, they will request what is necessary. But at the same time, the system can't just say this is new enough for you to take into consideration this lab result instead of requesting a new test. And I think that's the freedom that the patient start having.

Meriyem : And what about the GDPR and the right to be forgotten. If they share their data, can they come back and say I do not want this information to be shared anymore?

Natalia Monteiro : Yes, so this is the smart contract, so the way we do it with within our company is that the smart contract can be revoked. So the data that a patient shares, he can share either for a definite period of time. For instance, if I'm running a study and I want to find out, it would be interesting to run the study at the University Hospital of Zurich. Do I have enough participants with this condition and this condition, in this age group is there female working with one child? You know, it can be very specific, but I do not know. So what the industry is doing right now is that they say, OK, let's give it a try. So you set up the study, you engage nurses, you engage your study team and everybody, and then you start and after three months, you realize, oops, we have found just three patients that qualify and are interested. With a solution like ours, what we can do is differently. University Hospital of Zurich, they are interested in running a study. Great. So

what they can do is to get their patients' database. They already run the demographic because they also do not have all the health conditions of that patient. Right. The patient might have other conditions treated somewhere else, but what they can do is they go there and they run for the demographics. OK, she said female. It has to be between 40 and 65, great. This population is then reached by a survey. This survey is already perceived as right and the consent form is requested. So sharing this information, the whole purpose of this is to see if they qualify or not. So once they feel it, they already give the information if they qualify or not. And this information is not going to be stored, it's going to be destroyed because it's not the beginning of the study yet. So the whole idea is to select the right population. So if you do this, it actually turns out that three out of two hundred can participate in the study. And that's the key point. That's the key data point that we need to move forward. That's when they can go and make strategic decisions. Is it wise to start a study at the University of Zurich if we just have three people that are either willing or fulfil all the requirements and then maybe they decide, yes, let's do a decentralized trial, let's go for 20 different hospitals which have three patients who qualify. But then it's not going to be run by the University of Zurich. It might be run by Johns Hopkins Institute in the US who actually coordinates the whole decentralized trial. So that's actually an example of when it completely following GDPR.

Meriyem : Yeah, yeah, OK. And what about privacy? We often read that it is one of the benefits of blockchain. Is it encrypted?

Natalia Monteiro : OK, so, yes, it's a really important point. So, for instance, in this example I gave you, the only information that comes out is the number three, OK? Because that's what the third party requires from the hospital. They want to know if it's viable to run a study. So if you look at this, all the information that are shared is three. And this is totally respecting the two hundred patients that participated, correct? On the other hand, if they say no, we want this study, we want to run it, what happens? We need to go back and identify who are those three? Because now they are potential subjects. So you need to go back and identify and the hospital needs to have the right to use this data. And that's why it's so important to have this cloud security. So right now, the data is not sent to this third party, but it's utilized by the hospital itself. The hospital has had some consent forms with those two hundred at a certain moment in time, even myself, when I went for a skin condition, it was a very simple thing. I had to sign this at the hospital of Zurich so that I allowed them to utilize my data. So what happens then is that those three will be identified by the hospital just when they get the request to run a study and then when they get a request, there will be an ethics committee assembled. And this ethics committee is the committee who decides that the patient's rights are protected. So once this is set up, that's when those three can be found in the database. So there is a key and there is a possibility of recognizing who they are so that they can receive the next invite and the next invite will be just the same. They will receive an invite, which is a consent form, and asking them if they would be willing to participate in this study. And that's the second part. So I'm also a member of the Ethics Committee creating standards for blockchain. It's called IEEE. So there is a blockchain committee where we discuss in pharma what is ethically acceptable from the blockchain point of view. And those ethical committees were not meant to be bypassed.

Meriyem : OK, it's clear. Thank you. I think that we can go through the AI part. So how would you define AI?

Natalia Monteiro : OK, so A.I. is actually a way of making the most of the data sets we have. So there are models of optimising the utilization of all the data and the process that we have.

Meriyem : OK, as you know, I'm looking at the issues of A.I. So according to you, what are the ethical or technological issues that A.I. is currently facing?

Natalia Monteiro : So what I think is that there is a lot of discussion about replacing employees. What I believe is that AI actually is enhancing, you know, our cognitive capacity. It's not to replace, but it's to work next to it. I understand it will be replacing a lot of low level jobs. And there is an author who says that the future of humanity is to work less. So what I believe, you know, what he said was that our future is actually to work less, but to work more meaningfully. And this is hard for people to grasp because he is a philosopher, but it's a bit hard for us to grasp because society has been made with certain working hours and certain behaviour. But what he forecast back then was that there would be a shift so less and less people will be low skilled. But going into more high skilled in this transition, there will be a lot of suffering because a lot of employees are not capable or they do not have the age or the skills to obscure that fast. And I think that we go into another discussion, which is the minimum wage. So should government establish a universal wage. So it's a universal basic wage. I think even Elon Musk discussed this, that is necessary for this transition period where you have workers that are low qualified and they need to move into this. So actually, the whole society needs to work together in order to make sure that there is more pluses and minuses with implementation of A.I. But, you know, even when I see my work, when AI see being implemented, it actually has just enhanced, you know, of course, I'm not doing what I used to do. So 14 years ago, I was creating forecast models and I've done that all by hand with Excel. Right. And of course, I was deciding which kind of variables I was adding. Is it the job growth? Is it population growth? And so on. So my model was always enhanced by the figures I've decided and in an AI model, it's a combination of both. So AI is going to kick on patterns that me with my own eyes and the amount of data that I can compile will never be caught. And at the same time, AI will miss on a lot of variables that just a human can provide. And I think this collaboration participation is really a game changer when I go back to clinical trials. And that's why I'm so passionate about this, it is because there is just 10 percent of the world diseases being researched or with a solution in place. So we have a potential of 90 percent of diseases that are under study. And the reason for that is because we do not have enough resources. And I think this is a societal problem because guess where most of the population live and suffer. It's mostly in developing countries and pharmaceuticals are not interested in developing drugs that cost a lot to sell or to give away. Therefore, what we need to do is to reduce the cost of drug development. If the drug development is optimized, more population can receive it. And the way I see AI is that AI can actually avoid studies that are definitely going to be a failure because with the models, they can forecast. And the FDA this year has accepted for the very first time a drug in the market. It's not the first use. OK, so it's a second label for the drug. So there were already some studies. So the safety studies were in place. And I do not know if you know what safety studies is? This is that this drug is not going to kill patients, OK, just to take the drug per see. But and so for the second label, it was using an AI model to prove that the side effects were so positive for the second use. So instead of being a negative side effect was a positive side effect, therefore it could be used as a prescription. And the FDA for the very

first time has accepted. So now just think about it. You know, we have now discovered a drug that has already been discovered and this was just possible because of an AI model. Of course, it could have been possible with our traditional models, but the combination of both is going to speed research.

Meriyem : OK, makes sense, and now if we want to go a little bit into how blockchain and AI can work together. I do not know what you think about this, if it's possible or not. About the data management, do you think and how is it possible that blockchain can help the accessibility to data that we used to train AI?

Natalia Monteiro : OK, so what I believe is, for instance, right now, we have got those silos right. So let's take a very important research, which is Alzheimer we have seen in the last years a lot of failures. So it's a very costly research. And most of the drugs research so far have come to a failure. Pharmaceuticals, they give up on the studies and all the data on the failure is lost. But if we think about it, this is an excellent starting point for the next study, because they will really understand population health demographics only by applying A.I. models in the compilation of all those results. So you can actually use an AI model to either understand if the study set up was wrong, if the drug was wrong, if the population selection was wrong. And this can enhance the development. And that's how I see that the accessibility of this data is possible. One of the solutions I've come in contact with, is a company that is trying to develop molecules, which is one of the basic structures of any drug. But to develop it collectively. Again, some of those ideas, they are a very revolutionary. But the idea is that a molecule can be used for several drugs, not only one drug or one use. So his idea is that collectively they develop the molecule and they own the molecule collectively. Then what they individually, they get the rights to use that molecule for a certain disease and then they start researching. So if the molecule has been found out by this consortium and it's now in the blockchain, every partner of this consortium is allowed to use the molecule, but for a different disease area where it can also be agreed within this. So they will get their portion. So one person or one company or one research institute decides to investigate this molecule in a compound for Alzheimer, for instance. And that's when they can share the molecule development, they can share the knowledge of the molecule in a certain disease. So to wrap up, there is in the pharmaceutical company I was working for, we were looking at two models where you can actually apply AI into a blockchain where you do not need to reveal the data, so the model goes inside, checks for the result and comes out with the answer. In the example I gave you about, if we would turn the number three, four participants in that example, for instance, an AI model, could go in, could run inside the blockchain, you could run inside the clouds, behind the multiple clouds behind this blockchain and turn now to the number three. So that's also possible. We were looking into this not for patient data because this is more critical, but it was in a supply chain model. So we wanted to look, for instance, in a supply chain. We have got some pharma compounds that need to be traced, the temperature traced. So we need to make sure that by each stage of the supply chain, the temperature has been kept. The request was, please show up if there was any temperature's change and bring the results and the batch numbers and then it comes out. So actually it's evolving quite fast, AI models and compatibility. Perhaps there are not enough studies, but I know that in practice there are companies already utilizing it.

Meriyem : And can blockchain also help to increase the transparency and the traceability of the data that are used within the artificial intelligence machine.

Natalia Monteiro : I find this quite difficult because I haven't read too much about this topic, so actually I would like to ask you if you could share, you know, if you have all your articles in the Dropbox or Google Drive, if I could have access, because you seem to have access to really amazing material and I would be interested in browsing through the articles you have used for your dissertation. Yeah, I do not see the need to trace AI because when you look at the model itself, you can always go back just by the model itself. You know, you can always understand how it has been calculated, at least the ones I've worked with so far. So you see how it has done a certain estimation. And you can look into this so you can look into the record. But for a doctor, it would make real sense. I was looking to one solution, which is by a blood drop, if you look through a special lens, IBM is working on this machine, so you do not need to examine the blood. Just by the way, the shape, the molecules of the blood, it looks like the AI model can already recognize cancer. OK, so how would the doctor tell better? You know, because this is based on hundreds and hundreds of comparisons of pictures with pictures. And this is always evolving. So, you know, they learn from their mistakes and then they keep in involving so that tracing the diagnostic, I find it doesn't need to be on the blockchain, to be honest. But I think what is important is actually to utilize A.I. where it is really needed. And it's the same with blockchain. So it's a fantastic solution. It can be used in many situations, but always with a critical eye, because even if someone can be diagnosed with cancer based on how the molecules of the blood are done, we can't forget that the lab person could have mixed the blood samples. And that's when you have the human errors. So even the best AI model used runs the risk of a human error. But again, coming back to your question, I do not think there is a need for traceability, or at least I have not seen a list for a need for traceability.

Meriyem : OK, and do you think that using, for example, blockchain and ensuring that we know from where the data re from, that they are quality data, can help AI to make better decision based on data? I mean, we are sure that the data fed into the machine are not tampered?

Natalia Monteiro : I think this is a constant struggle. I've worked with data since I started working. OK, so the largest challenge for everyone working with data is data quality. And this is 80 percent of any piece of work. It's actually going through your data, cleaning our data, making sure, you know, you become the bodyguard of your data. And I think this is the most important part. What we have seen as well with some of the models is that they are very male driven because the data source was male driven. So it does not actually reflect and this is a problem. But there is always a solution, so I know someone who is working on a female development drugs, and we know that there is a lot of bias in AI to females and there are other applications where you see this. So, for instance, for a credit rating in the US, a lot of banks, they use AI to create fast models for credit rating so that they can define very quickly who gets the credit and who shouldn't. But because they are very male driven, a lot of women actually get a negative and it's actually wrongly done. If it would have been done by a person, that person would have gotten the credit. And that's actually quite a big problem. But also the problem is that when you work at the drug development, male bodies and female bodies are intrinsically different. So muscle mass, bone mass, stature, all of this. So there are some studies in the market that prove that women are actually over dosed because they do not need the same amount because their bodies are smaller. But the market is not interested in developing two packages. Or to start with personalized medicine and in a sense, this is a problem, right? We could say the model is biased, but the whole model was biased. But with A.I., you can actually solve that

and that's what this scientist is working on. She is actually utilizing A.I to filter just the female results of the studies and to provide more accurate data. So creating more personalized medicine for females. And that's what I find so powerful. Yes, it can create biases, but by recognizing where the mistakes are, you can utilize the same system that creates the bias to actually personalize it.

Meriyem : OK, but then here the blockchain doesn't interfere?

Natalia Monteiro : I think it's actually separate. So just to wrap up, how I would like to wrap this up is that I do not think the blockchain helps AI. I think it's vice versa. I think it's artificial intelligence tapping on the potential of blockchain, because now if we go back to the beginning of my answers blockchain is actually helping decentralized databases being connected so that mental hospital, the heart hospital, the dermatologist, the GP, imagine that all this data remains in their silos, but via the blockchain, the patient actually can collect specific data from the different silos. Now, if you put an AI model on top of it, then you actually can tap on all the information that is collected and secured and kept in the silos. So whatever you ask your AI model to do, he is now actually having no boundaries. And that's what I find powerful of this whole system, but to trace how that A.I. model has worked, I find it either is just pure ignorance from my part because I haven't really looked into this or I'm missing this opportunity. I know some people are angry, some people are not. So I do not still know who is right and who's wrong.

Meriyem : But do not you think that blockchain can help to access better data for AI or not, in conclusion?

Natalia Monteiro : Yeah, definitely, because my answer is yes, because blockchain allows access to silos that before, would have never. So actually improving your AI model by the amount of information you are feeding in.

Meriyem : And can it help them with bias to reduce bias because the data are quality data?

Natalia Monteiro : Yeah, yeah.

Meriyem : Do you think that in the future, because now it's really nascent, but in the future, that the two technologies will be able to merge and to provide, like, for example, better data for AI?

Natalia Monteiro : I do not think they really will merge. They might they might not. What I think is, those are two powerful technologies. I see how powerful it can be when applied to the data. But to be honest, I've also seen some of our customers utilizing it without A.I. because it's a small amount of data and it can be done by an individual. So I do not think one requires the other. What I think is there are some areas where AI can be extremely powerful when combined with blockchain, because once you have got the traceability, the security, transparency of blockchain and access to more data, AI goes to another level because that's what AI needs, AI needs data. The better the more, the better is going to be a result. And I think blockchain could be a catalyst to it, but not necessarily.

Meriyem : Perfect. I won't keep you any longer. You have to leave. Thank you very much for your time. It was really valuable. Thank you.

Natalia Monteiro : Thank you. It was a very, very nice was a pleasure. Again, if you could share the articles you were reading, I'm very interested in this topic.

Meriyem : I'm going to share them with you. No problem.

Meriyem : Thank you very much and have a nice day.

Natalia Monteiro : You too, bye

Interview Jonathan Passerat-Palmbach

Meriyem : Bonjour, vous allez bien ?

Jonathan Passerat : Ca va et toi ?

Meriyem : ça va, merci beaucoup. Tout d'abord, avant de commencer, m'autorisez-vous à enregistrer le call à des fins académiques et à utiliser les informations pour ma recherche exploratoire ?

Jonathan Passerat : Bien sûr, pas de problème.

Meriyem : Merci beaucoup. Je vais me présenter brièvement. Je m'appelle Meriyem, je suis étudiante en 2^e année de master en ingénieur de gestion en Belgique et je termine ma dernière année avec un mémoire concernant la blockchain et l'AI avec plus précisément pour question : *"Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence?"*. Pouvez-vous également vous présenter rapidement ?

Meriyem : D'accord, j'en apprend des choses. Pour expliquer brièvement comment se passe l'entretien, la première partie, c'est plus pour définir comment la blockchain fonctionne, ses avantages et ses inconvénients, etc. Puis voir un peu quels sont les problèmes de l'intelligence artificielle au niveau éthique, donc tout ce qui est légal, security, discrimination, etc. Et après la partie qui suit, moi, justement, c'est pour voir comment est-ce que la blockchain pourrait diminuer, voire supprimer certains problèmes que l'AI fait face. Et après c'est utiliser le technology acceptance model. Je ne sais pas si, si vous connaissez. C'est un modèle permettant de voir si c'est vraiment possible d'intégrer les 2, etc. Je vous expliquerai à ce moment-là. Mais c'est vrai que quand je lisais dans toute la littérature du mémoire, quand on regarde pourquoi la blockchain pourrait aider l'IA, la première, c'était vraiment au niveau des data. Le fait d'amener les data, justement, de manière plus ciblée, de meilleure qualité, etc. Puis la deuxième, c'était de prendre des décisions collectives. Et alors, la troisième, c'était d'avoir une AI qu'on peut expliquer grâce à la blockchain. Et alors le fait que on peut aussi monétiser les data des patients qu'ils auront entre leurs mains.

Jonathan Passerat : Alors moi je suis chercheur en informatique, j'ai fait une thèse en calcul haute performance, calcul distribué et je me suis orienté vers un labo d'imagerie médicale où du coup, on utilisait, on utilise d'ailleurs toujours des techniques de machine learning d'intelligence artificielle pour analyser les images médicales qu'on avait à disposition. Et c'est là que j'ai commencé à développer un intérêt, en premier lieu, pas forcément pour la blockchain. C'est venu un peu en même temps, mais surtout pour tout ce qui était le partage de données en fait. Je travaillais dans un projet qui collectait des données assez rares et assez coûteuses, et on avait comme but dans le projet de les partager avec la communauté scientifique. En fait, je pensais que les complexités viendraient plutôt du côté technique puisque c'étaient des données assez larges. Mais finalement, ça, on l'a résolu de manière assez triviale. Par contre, on va dire que les problèmes étaient plutôt sur le côté administratif et légal en fait de comment on peut partager des données même ne serait-ce qu'à l'intérieur d'une même université, entre l'hôpital et l'université, des fois, c'est pas évident de faire du partage de données et du

coup, je me suis rendu compte que le partage de données, ça ne marchait pas et qu'il fallait trouver autre chose. Et surtout, surtout pour l'intelligence artificielle. Et c'est à ce moment-là, en fait que j'ai rencontré des gens qui travaillaient dans ce qu'on appelle le privacy preserving machine learning. Donc, je ne sais pas comment on dit en français, mais le machine learning sur des données privées, on va dire. En gros, c'est toutes les techniques qui permettent soit d'entraîner des modèles, soit de faire des prédictions sur des modèles existants sans jamais voir les données. Et parfois même sans déplacer les données. Du coup, je me suis dit en fait c'est top parce que c'est exactement ce qui manquait dans mon problème, en fait du coup, parce que si je n'ai pas besoin de déplacer les données, je n'ai plus besoin de l'accord de tout le monde. Ou du moins, j'ai besoin d'un accord, certainement beaucoup plus simple à obtenir si j'ai des garanties comme quoi les données restent encryptées, comme quoi elles ne bougent pas en fait. J'ai commencé à travailler sur ça et à la même époque, en fait, j'étais un peu curieux de ce qui se passait au niveau blockchain Ethereum, etc mais vraiment en termes de hobbies. Et en fait, un peu par accident, ça a rejoint mes thématiques de recherche d'avant parce que j'ai trouvé des projets blockchains qui cherchaient à faire du cloud computing décentralisé. Et qui en gros grâce aux incentives qui étaient mis en place par les crypto tokens, ils arrivaient à résoudre des problèmes qui étaient assez difficiles en termes de calcul distribué pour garantir la qualité des machines qui étaient mises à disposition sur un cloud décentralisé. Il y a un projet qui cherchait à analyser les signaux d'un télescope si je ne dis pas de bêtises pour détecter des signes d'activité extraterrestre. L'idée, c'est que ça prenait énormément de temps de calcul et que, du coup, ils ont développé un petit programme de calcul distribué pour permettre aux gens qui le souhaitent, aux volontaires sur Internet de mettre à disposition leur ordinateur en installant ce programme sur la machine. Et quand leur ordinateur ne faisait rien, en fait, il leur envoyait des choses à calculer pour avancer sur l'extraction de données de ce côté-là. Le problème, c'est que du coup, c'est devenu tout un mode de calcul qui s'appelle Volontere Computing. Et c'était très dépendant de la qualité des machines des gens, de leur capacité à laisser les machines en ligne. Du coup, il y avait énormément de problèmes sur la possibilité de finir un calcul dans un temps précis et sans avoir des morceaux qui manquent. Du coup, en calcul distribué, on a développé pas mal d'heuristique on va dire pour pallier à ce problème ou en gros, on dupliquait les tâches à exécuter pour qu'il y en a certaines qui reviennent etc. Et en fait, quand la blockchain est arrivé avec ses projets de cloud décentralisés, ils ont dit on va forcer les gens qui veulent mettre à disposition leur machine à miser leur token. Et du coup, s'ils sont confiants qu'ils peuvent produire une qualité de service assez haute, on va les récompenser plus. Par contre, s'ils ne respectent pas leur contrat, ils vont perdre des jetons et du coup, ça permettait d'éviter toutes ces heuristiques un peu, un petit peu un peu simpliste et de mieux optimiser ça. Donc ça, c'était vraiment mon introduction à la blockchain, en fait. En fait, il y a peut-être quelque chose d'utile là-dedans. Ce n'est pas que du buzz et des gens qui cherchent à devenir riche. Et en fait, à ce moment-là. J'ai rencontré des gens de ConsenSys. Du coup, ConsenSys, l'entreprises principale qui travaillent exclusivement sur Ethereum et en fait, il cherchait à intégrer dans leur équipe de recherche des thématiques autour du calcul privé justement. Donc, pour moi, c'était le bon moment pour rejoindre les 2 trucs qui m'intéressait. Et donc j'ai rejoint Consensus en 2018, décembre 2018 pour travailler sur ces thématiques là et en fait, assez rapidement, on s'est rendu compte qu'il y avait beaucoup d'intérêt pour la finance chez ConsenSys et en finance, il y a beaucoup de choses à faire avec la blockchain et juste la blockchain. Par contre, on a rencontré des gens dans ConsenSys qui eux travaillaient exclusivement sur les données de santé et sur la santé et la blockchain et à l'inverse, eux, avaient du mal à

vendre le 100% blockchain pour les données de santé, puisque les gens étaient un peu réfractaires à ça. Par contre, quand on leur a présenté ces méthodes de calcul privées, ils se sont rendu compte que c'était peut-être beaucoup plus pertinent que forcément la pure blockchain. Dans le cas des données de santé. Et on a commencé à travailler ensemble et on a créé ConcenSys health, spinoff de ConsenSys juste dédié sur la santé, dont le but est d'exploiter au maximum ces techniques de calculs confidentiels calculs privés, mais en lien avec la blockchain. L'idée, c'est que ces techniques de calcul privés, on les utilise principalement pour faire du machine learning. Du coup, c'est là, c'est là d'où vient le lien, entre autres tout ce que je fais sur le côté machine learning, calcul privé. Et comme on raccroche la blockchain à tout ça. Si on veut aller, on va dire non dans le haut niveau. La blockchain, en fait, ça sert à avoir une chaîne de confiance, en fait de par exemple, tous les événements qui se sont passés dans un système et que tout le monde s'accorde sur la valeur d'une certaine action par exemple. Quand tu fais du machine learning en réseau entre plusieurs sites qui collaborent pour le coup, mais qui ne sont pas forcément amis, qui peuvent être des compétiteurs, ils veulent avoir la preuve que ce qui s'est passé est vrai. Une des manières les plus simples, en fait, d'utiliser la blockchain dans ce contexte, c'est de s'en servir comme un journal d'évènement irréfutable où tout ce qu'on fait sur les données dans un réseau, on va le loguer sur la blockchain et tout le monde va participer à ce réseau. Du coup, on va augmenter la confiance en fait du processus d'entraînement du modèle de manière distribuée. C'est vraiment l'étape zéro de la fusée en fait, on va dire c'est ce qu'on peut faire assez facilement et qui parle aux gens. Là où ça devient très intéressant, et où je pense qu'il y a une vraie synergie et encore plus quand on parle de données sensibles comme des données de santé, en fait ses techniques, on va dire qu'il y a deux grands plans. La première technique dont je parlais en termes de machine learning distribuée s'appelle le federated learning. C'est une technique qui a été développée, en particulier par Google. Et ils s'en servent pour faire quoi ? Ils s'en servent pour dire, on a les claviers sur Android, qui prédisent en fait les mots, les mots suivants pour que tu puisses taper plus vite quand tu envoies des messages. Et ça, bien sûr, il y a un modèle d'IA derrière qui fait la prédiction, mais il l'entraîne à partir des données utilisateurs. Donc, il y a deux options. Soit il récupère nos données sur un serveur central, les données de tout le monde, les miennes, celles du voisin, et il entraîne leur modèle sur ça. Ça marche. Mais par contre, niveau confidentialité, ce n'est pas terrible du tout parce que ça veut dire qu'eux, déjà, peuvent voir en clair les messages qu'on envoie, que potentiellement, c'est mélangé avec d'autres messages, que s'il y a une fuite de données. Nos messages sont souvent perdus dans le vide, donc ce n'est pas terrible du tout. A l'inverse, ce qu'ils ont commencé à faire, c'est au lieu de déplacer les données, ils envoyaient les modèles sur les smartphones et du coup, chaque personne entraîne le modèle un peu, beaucoup moins bien sûr, que sur une grosse quantité de données, sur les données qu'il y a sur son smartphone, donc sur les messages envoyés sur ce que tu as tapé avec ton clavier, etc. Ce que ça fait, c'est que ça te donne un nouveau point, une amélioration du modèle. C'est la tienne. Et tu dis, moi, je pense que pour améliorer le modèle, pour qu'il soit plus précis à prédire mes prochaines phrases, il faut qu'il aille dans cette direction. Moi, je dis en fait par rapport à ce que j'ai tapé, je pense qu'il doit aller dans cette direction, il y a un troisième qui dit moi, je pense qu'il doit aller dans cette direction et ce que fait Google, il récupère juste ces vecteurs-là, en fait, et ils font en fait la moyenne de ces vecteurs et ça leur donne une direction moyenne dans laquelle faire évoluer le modèle, en fait, pour qu'ils apprennent mieux. Et ça, du coup, c'est privacy preserving parce qu'à aucun moment, ils ont eu accès aux données de base, ils n'ont eu accès qu'au résultat d'une étape d'apprentissage du modèle. Ça marche bien parce que Google contrôle la stack d' A à Z, il

contrôle le smartphone, il contrôle l'IOS sur le smartphone, il contrôle les applications, il contrôle le modèle. Ils font ce qu'ils veulent avec. Maintenant, imagines, tu veux faire la même chose entre plusieurs hôpitaux, par exemple, ou entre plusieurs entreprises qui ont des données sensibles. Ils ont chacun leur système. Ils ont chacun potentiellement leurs données qu'ils ne veulent pas révéler aux autres. Et ils disent que c'est une bonne idée de potentiellement mettre en commun ces données pour avoir un modèle qui leur permettra à chacun d'aller plus loin. Par contre, ils imaginent bien qu'ils ne vont pas forcément tous faire la même contribution, en fait pour les modèles. Donc, peut-être qu'il y en a un qui a plus de données. Peut-être il y en a un qui a des données beaucoup plus spéciales. Du coup, il va emmener le modèle dans une direction différente et lui montrer des exemples qu'il n'avait pas forcément vu avant. La question, c'est comment fait-on pour représenter, comment fait-on pour potentiellement calculer la contribution de chacun ? Qu'est-ce qu'on peut faire avec cette contribution ? Et c'est là que la blockchain entre en jeu. Parce qu'à chaque fois que tu parles de contribution de quantité comme ça, c'est quelque chose que tu peux représenter en token de la blockchain. Après ce que tu fais, c'est à toi de décider. Tu peux situer dans un réseau qui a besoin d'incentive financières. Tu peux dire en fonction de ces contributions, tu vas gagner plus ou moins de token, en fait, sur ce que tu as contribué. Là où ça devient vraiment très cool, c'est que tu peux aussi dire ben en fait, on va faire de la gouvernance avec ça. On va dire toi, tu as contribué à 45% du modèle. Donc du coup, ça va te donner autant de parts dans le modèle. Et avec ces parts-là, tu vas pouvoir décider si on continue d'entraîner le modèle, si on accepte de le mettre à disposition d'une entreprise, par exemple, qui ne nous paraît pas forcément éthique. Donc là, on va pouvoir voter et on va pouvoir dire OK, tu peux l'utiliser, tu ne peux pas l'utiliser. Ça, tu peux le faire très bien avec des papiers et un crayon et se dire on se rejoint tous autour d'une table, on vote et on décide si oui ou non, on met notre technologie à disposition. C'est le côté éthique et c'est, j'imagine, ce qui se fait à l'heure actuelle. Qu'on peut prendre des décisions d'utilisation plus ou moins éthiques. Avec la blockchain, on peut le faire de manière complètement autonome parce que si c'est par le modèle, elles sont enregistrées. Et qu'est-ce qu'elles sont en fait ? Elles sont des éléments cryptographiques qui vivent sur la blockchain, qu'on peut combiner avec des actions qui se passent en dehors de la blockchain. Donc, si, on combine, ça fait avec les techniques de calcul confidentiels dont je parlais avant et qu'on dit OK. Le modèle, il est encrypté de toute façon. Donc, on peut le mettre à disposition de tout le monde. Mais quand quelqu'un fait une requête pour pouvoir y avoir accès, on va se retourner vers la blockchain pour savoir qui a les parts, on va faire un vote avec les partis sur la blockchain dans un smart contract, par exemple, complètement de manière autonome. Et à partir de ça, en fait, on va oui ou non débloquent l'accès au modèle qui lui est crypté. Donc on va pouvoir complètement automatiser, en fait, ce qu'on ferait avec du papier et du crayon dans une salle de board management. En fait, dans un meeting de board en utilisant à la fois la blockchain et la cryptographie sur les machine learning, on commence vraiment à voir des applications de synergie entre ces deux domaines. Il y a énormément de bruit dans ce domaine et je trouve qu'il y a énormément de choses qui ne sont pas très innovantes ou en gros, le but, c'est juste de dire on utilise de la blockchain. Et je ne trouve pas ça très intéressant. Et je vois justement beaucoup d'applications, je reviens sur les data sharing ou en gros, ils utilisent la blockchain pour dire on utilise la blockchain pour enregistrer le consentement d'un patient à partager ses données avec un médecin, avec une compagnie pharmaceutique c'est pourquoi je ne peux pas faire la même chose avec une base de données normale ? Pourquoi j'ai besoin de la blockchain pour faire ça. Moi, je ne sais pas. Je pense que je n'en ai pas besoin. Si en fait, la blockchain que tu utilises, elle est contrôlée

à %100 par les entreprises, c'est à dire que ce n'est pas une chaîne publique et que tout ce que tu fais avec, c'est de dire j'enregistre que monsieur X il a tapé sur son smartphone pour dire OK, je partage mes données avec docteur X en clair. La blockchain elle ne sert à rien parce que monsieur le patient, il n'a pas du tout accès à la blockchain. Lui il n'a pas son nœud de blockchain. Donc, ce qui se passe sur la blockchain, il n'a aucun contrôle dessus. Je pourrais avoir une base de données ça serait la même chose pour lui, il n'y a aucune différence. Deuxième problème une fois qu'il a donné son consentement pour que ses données soient vues par quelqu'un d'autre. Concrètement, ce qui se passe, c'est que la donnée sur son smartphone ou sur son cloud à lui, on la copie. Il y a une deuxième donnée identique qui arrive sur l'ordinateur du docteur, de la pharmacie ou autre. Et à chaque fois qu'il fait ça, à chaque fois qu'il donne son consentement, copier, copier, copier, copier, copier, copier. Et à chacune de ces copies, il y a deux problèmes qui se créent. Tu as de plus en plus de chances que même si les gens font attention et sont très honnêtes, à un moment donné, il va y avoir un leak et ça donnée à lui, elle va être perdue alors qu'il avait donné son consentement juste pour une utilisation. Et ensuite, un deuxième problème, c'est que si tu veux introduire des mécanismes économiques, des mécanismes de marché, plus tu crées de copies, plus tu fais descendre la valeur, la valeur de ce que tu as fait, puisque là, la valeur, elle, vient de la rareté. Donc, si tu crées des copies de quelque chose qui à la base est rare, plus tu le mets à disposition, plus tu le copies, ben moins ça a de la valeur parce que tout le monde l'a en fait. C'est comme à l'époque, quand on a commencé à graver les CD. En fait, plus personne ne voulait acheter de CD parce que tu pouvais créer des copies gratuitement. Donc, la différence, c'est que si maintenant le patient a la possibilité non pas de copier ses données, mais de dire OK, je te donne accès, mais ma donnée reste encryptée, tu ne peux pas la voir, tu peux faire des calculs dessus et tu peux faire seulement les calculs que je t'autorise. Et je peux vérifier les calculs que tu as fait parce qu'ils sont tracés sur la blockchain. Là, on change, on change de jeu. Parce que lui, s'il a une donnée qui a de la valeur, il n'a pas besoin de la copier. Il va juste donner l'accès et en fait, on passe d'un système où on fait du data sharing à un système où on fait du data lending ou en gros, lui, il va pouvoir louer la donnée et garder sa confidentialité en même temps. Et ça, c'est extrêmement puissant, je pense. Et ça va beaucoup plus loin que tout ce qu'on voit à l'heure actuelle sur des data sharing. Et faire de la blockchain pour du data sharing, ça sert à rien.

Jonathan Passerat : Ça ressemble globalement à ce que je vois souvent oui. En fait, si tu veux je ne suis pas contre les grandes lignes, mais souvent, en fait, quand tu creuses derrière, tu vois que la plupart des projets ils n'ont pas la solution pour que ça marche vraiment. Ou alors ils ont une solution mais ça va être limité. Typiquement, en fait, c'est le dernier que tu disais, c'est le fait de donner le contrôle aux patients pour qu'ils puissent extraire de la valeur de leurs données. Si tu veux copier, en fait, bah, ça ne marchera pas. Tu ne peux pas faire ça, tu seras très limité quand tu vas le faire.

Meriyem : Pour commencer, comment définiriez-vous la blockchain ?

Jonathan Passerat : C'est pour moi une base de données distribuée en laquelle on peut faire confiance.

Meriyem : Comment fonctionne-t-elle ? Qu'est-ce qu'elle peut apporter ?

Jonathan Passerat : Elle fonctionne en fait comme tout système distribué, c'est à dire qu'elle a besoin d'avoir un accord, de trouver un consensus pour savoir dans quel état est

le réseau. Et la différence, en fait, avec un système distribué classique, c'est la manière dont elle trouve ce consensus. C'est que pendant très longtemps, en fait, il était difficile d'arriver à un consensus sur un réseau, sur un très grand réseau où on ne se faisait pas confiance. Et en fait, certaines nouvelles technologies de blockchain ont permis de faire ça, comme par exemple avec PoW dans Bitcoin. Ce qu'elle peut apporter pour moi, c'est principalement quand on est sur des réseaux publics, je pense que, du coup, tu as dû voir la différence entre les chaînes privées, les chaînes publiques. Globalement, une blockchain privée, c'est une base de données distribuée. C'est bien pour faire des tests, c'est bien pour donner de la confiance entre certaines entreprises, mais dans la plupart des cas, si tu pousses un peu, tu vas te rendre compte que tu pourrais le faire, que tu pourrais implémenter ton use case avec autre chose que la blockchain. Maintenant, quand tu passes sur une blockchain publique, le côté immuable en fait. Le fait que tu ne puisses pas modifier, que ce soit en lecture seule et le fait qu'il soit très difficile de tromper le consensus fait que tu as confiance en une source de données publiques que tu n'avais pas avant. C'est vraiment cet aspect de chaîne publique qui je trouve, fait la différence avec ce qu'on avait avant.

Meriyem : Durant mes interviews, les gens étaient un peu mitigés concernant le fait d'utiliser une blockchain public ou privé au sein du domaine de la santé, en partie parce que les data sont assez sensibles, vous pensez que laquelle est mieux ?

Jonathan Passerat : Public. La raison pour moi que les blockchains privés, je ne dis pas que je me s'en sers pas, on s'en sert assez bien. Mais ça ne doit pas être la finalité. Si la finalité de ton réseau, c'est de mettre en place une blockchain privé, je pense que tu pourrais le faire autrement. Ou alors tu utilises le terme blockchain à tort et on fait ce que tu fais c'est vraiment une base de données distribuées, je pense pour moi. Pour moi, la plus-value est très faible. Quand tu es sur un réseau privé, tu vas te mettre plus de contraintes qu'autre chose. Et pour des taux de transactions beaucoup plus faibles que sur une vraie base de données distribuées.

Meriyem : Avez-vous quelque chose à rajouter par rapport aux avantages ?

Jonathan Passerat : Non, je pense que c'est vraiment ce côté non modifiable, non censurable. Finalement, c'est une infrastructure plus qu'autre chose. Ça doit être un service, presque un service public comme internet qui permet à tout le monde, en fait, d'avoir une base sur laquelle se reposer, sur laquelle il sait qu'il pourra toujours accéder, que personne ne pourra l'empêcher d'accéder à ce réseau. C'est à disposition.

Meriyem : Et les inconvénients ?

Jonathan Passerat : Les inconvénients, si on est très pragmatique, on va dire qu'à l'heure actuelle, il y a encore des problèmes d'évolutivité, le passage à l'échelle en termes de nombre de transactions qu'on peut faire tourner. Je pense qu'au niveau problèmes, on n'en a aussi pas mal, en fait, la multiplication des réseaux de blockchain. Mon avis n'est pas totalement fondé sur cela donc je réfléchis en même temps. Je ne sais pas si c'est bien qu'on ait beaucoup de blockchains. Je pense en fait, ce qui va arriver à terme, c'est ma vision, peut-être ce n'est pas vrai, mais j'imagine qu'en gros, il va y avoir une blockchain publique, qui va émerger, qui va être dominante. Un peu comme je ne sais pas. Tu vois, il y a eu la guerre entre le DVD et un autre format à l'époque et c'est le DVD qui a gagné. Ça

ne veut pas dire que l'autre truc était moins bon, c'est qu'à un moment donné, il y en a un qui s'impose. Et tout le monde se sert de ça parce que c'est le support par défaut. Après, je pense qu'il y aura peut-être d'autres blockchains spécialisés, publics ou non, qui seront par exemple pour tel réseau, pour tel consortium entre entreprises, pour ces choses-là. Mais la manière dont je le vois fonctionner à terme, c'est que tous ces sous réseaux, toutes ces sous blockchains, elles auront toutes la capacité de se raccrocher à la blockchain principale. Et je pense qu'il y aura une sorte de backbone de l'internet par une blockchain publique auquel tout le monde aura accès, qui sera cette source de confiance entre tous les protocoles qu'on pourra développer et qui eux-mêmes pourront développer leur propre sous chaîne, leur propre sous réseau.

Meriyem : Une autre question est comment la transaction est-elle cryptographiquement signée ?

Jonathan Passerat : Alors, ça, ce n'est pas vraiment grâce à la blockchain, c'est le fait qu'une blockchain, il y a cette notion de chaîne de blocs, de blocs de données qu'on ajoute petit à petit et la manière dont on représente les personnes, les comptes, les utilisateurs sur la blockchain, c'est par une clé privée. En fait, quand on compte sur ton wallet, c'est la clé privée. Et ce que tu peux faire avec une clé, avec une technologie de clé privée comme ça, c'est d'une part signer une transaction ou signer n'importe quel message. Et une signature cryptographique, c'est quoi ? C'est juste montrer via une technique de cryptographie que tu possèdes une certaine clé privée. Et du coup, ça, ça veut dire quoi, ça veut dire que si tu possèdes cette clé privée, tu contrôles le compte qu'il y a derrière cette clé privée. Du coup, si toi tu signes une transaction, si toi tu signes un mail ou quelque chose, je peux avoir confiance que ça vient de toi puisque a priori, ta clé privée, y'a que toi qui la connaît. Sinon, t'as un problème avec ta clé privée.

Meriyem : OK, Je pense que du coup, on peut passer à l'IA comme ça après, on peut regarder un peu comment on pourrait mettre les deux ensemble. Mais tout d'abord, comment définiriez-vous l'IA ?

Jonathan Passerat : Pour moi, c'est la capacité d'un système à agir de manière autonome sur soit un problème unique, soit un ensemble de problèmes, soit complètement raisonné de manière autonome dans un environnement total comme un humain. Du coup, ça serait plutôt ce qu'on appelle AGI, Artificial general intelligence.

Meriyem : Et quels sont les challenges actuels, selon vous ?

Jonathan Passerat : Je ne sais pas si on va arriver à faire de l'intelligence artificielle générique avec les techniques qu'on a aujourd'hui et avec le matériel qu'on a aujourd'hui, je pense qu'on est en train de devenir très bon à résoudre certains problèmes, la reconnaissance d'images, la traduction de textes, des choses comme ça, c'est devenu la compréhension de Speech recognition. Il y a certains problèmes assez spécifiques qu'on arrive bien à faire, mais c'est marrant parce que je réfléchissais à ça ce week-end. J'ai loué une voiture et c'était la première fois que je conduisais en Angleterre et avec le volant à droite et conduire sur la gauche. En fait, quand tu réfléchis une IA pour une IA aujourd'hui, c'est encore difficile de conduire. D'accord, si tu regardes tout ce que fait, Tesla, Uber, tous les tests qu'ils font, ils commencent à arriver à avoir des véhicules autonomes, mais personne aujourd'hui signerait pour avoir que des véhicules autonomes partout dans la

rue parce que ça serait une catastrophe. En fait, ça veut dire quoi, ça ? La conduite autonome, c'est un problème qui est très difficile encore pour l'IA. A l'inverse, pour un humain que tu conduises à gauche ou à droite, tu conduits d'accord pour toi, tu arrives à t'adapter. En fait, tu fais assez vite abstraction du fait que tu doives conduire à gauche ou à droite. Par contre, pour nous, c'est hyper compliqué de se dire que maintenant, le volant est à droite et le levier de vitesse à gauche. Il est plus du côté où j'ai appris alors que pour l'IA, c'est l'inverse. Pour l'IA, si elle sait conduire de manière autonome à droite, à gauche, c'est exactement pareil. Donc, là où nous en fait, on arrive avec notre cerveau d'humain à s'adapter dans plein de circonstances pour faire un truc assez difficile qui est la conduite, l'IA n'y arrive pas encore tout à fait. Mais par contre, un problème très simple qui est très quadrillé, qui est de dire une fois que je sais conduire, si je me mets à droite, eh bien je reste sur cette ligne là ou si je me mets à gauche je reste sur cette ligne-là, ça l'IA est très bonne pour le faire parce que c'est un problème beaucoup plus borné, en fait. Et nous, on n'est pas bon pour le faire parce qu'on est trop câblé. C'est pour ça que je pense qu'on avance, mais je pense qu'on est encore loin.

Meriyem : Vous pensez encore à d'autre désavantages ?

Jonathan Passerat : On va dire il y a une sorte de désavantage un peu philosophique. Je trouve que les techniques sur lesquelles on s'est orienté aujourd'hui de deep learning. Elles ont deux contraintes assez lourdes pour moi, c'est que déjà, elles demandent énormément de données pour pouvoir arriver à un résultat cohérent et elles demandent en même temps énormément de temps de calcul. Et le problème, du coup, c'est que qui a énormément de données et énormément de temps de calcul. C'est les Google, Facebook, Amazon. Donc, en fait, on est en train de créer une sorte de monopole de centralisation de l'IA dans des labos de recherche privé. Attention les gens qui bossent là-dedans sont très bons. Il n'y a aucun problème avec ça. Par contre, je ne sais pas si les entreprises pour lesquelles ils travaillent ont tout le temps forcément une incitation à partager les résultats de la recherche de manière complètement ouverte et on l'a vu, il y a eu un petit débat sur Twitter il n'y a pas longtemps à propos de l'algorithme que Google a mis à disposition je crois que c'est pour le cancer du sein un truc comme ça ou finalement ça a été publié dans Nature. Et Nature normalement, il te demande de mettre à disposition le code, les modèles, les données et en fait, à chaque fois qu'ils font, arrivent à esquiver en disant oui, mais c'est des données privées, on ne peut pas. Oui, mais c'est du code trop compliqué parce qu'il est trop lié à notre architecture qu'on ne peut pas mettre à disposition de certaines personnes. Et on se retrouve en fait dans des situations où les seuls qui font avancer finalement le domaine, ce sont ceux qui ont ces ressources quasiment infinies, mais qui, en même temps n'ont aucun intérêt à divulguer de manière complètement transparente ce qu'ils font avancer. Donc, j'ai peur qu'on soit dans un monde, dans un système où la recherche académique avance plus vraiment dans ce qu'elle devrait faire. Pour moi, c'est ça le gros ou la grosse contrainte. On est tous en train de s'enfermer dans ce Fano du deep learning, alors qu'en fait, les seuls qui peuvent vraiment avancer de ce côté-là, ce sont les gros.

Meriyem : Donc si on reprend les problèmes que j'ai découvert au sein de ma littérature, en plus de ce que vous venez de dire, il y a des data quality, la provenance, d'où vient l'information, trust issues des patients et des médecins ou des praticiens qui ne font pas confiance en un résultat donné par l'IA. La discrimination et les biais. Cyber sécurité, la privacité et gouvernance. Donc ça, c'est vraiment tous les problèmes principaux. Selon la

littérature, de nouveau, la blockchain pourrait amener des réponses à certains de ces problèmes. Donc, sur base de ça, j'ai plusieurs questions déjà par rapport au data management, si on utilise la blockchain, est ce que ça peut faciliter l'accessibilité aux data qui serait utilisée pour entraîner les machines ? Si oui, comment ?

Jonathan Passerat : Pas seule. La blockchain, c'est une condition nécessaire, mais pas suffisante dans ce cadre, parce que, comme je le disais en fait, la blockchain seule ne te permet pas de sortir de cette boucle de data sharing. Et du coup, tous les problèmes que tu as évoqués avant sont aussi liés à la duplication de données, à la gouvernance sur ces données, en fait. A partir du moment où tu dupliques ta donnée, tu perds en fait toute possibilité de gouvernance. Tu peux dire dans ton application, non, j'arrête de consentir à ce que mes données soient utilisées pour entraîner cette AI. Mais la donnée elle a déjà été copiée. Tu n'as aucun moyen de prouver que ta donnée a été supprimée. Aucun moyen. Et ça, ça, c'est dans le GDPR, tu as le right to be forgotten. Le right to be forgotten, à l'heure d'aujourd'hui, c'est remplir un formulaire. Et voilà, on te dit OK, c'est fait, mais tu ne peux pas le prouver. En fait, tu arrives à des situations totalement ridicules. Par exemple, nous, dans notre exemple de data sharing que j'avais à l'université, on avait fait ce critère de right to be Forgotten. Et on te demande en fait, une fois que tu as diffusé tes données à plein de labos dans le monde, peut être 100, je ne sais pas. 200, on te dit. Si un patient décide de se retirer, il faut que tu garantisses que toutes les copies de ces données ont été supprimées. Mais je ne peux pas. En fait, physiquement, c'est impossible. Je ne peux pas aller dans chaque site et dire que tu as bien effacé.

Meriyem : Et il n'y a pas moyen d'accéder à la donnée sans la dupliquer alors ?

Jonathan Passerat : Si, justement, si tu, si tu amènes le calcul à la donnée au lieu d'amener la donnée vers le calcul. Ou si tu sais, deuxième moyen, c'est si ta donnée reste encryptée la partie, là, quelque part, ce n'est pas grave si, la donnée encryptée est copiée puisque si t'as pas la clé pour la déchiffrer, c'est qu'il y a du binaire sur ton disque, tu peux rien faire. Donc là, c'est là où on fait en maintenant m'a donné encryptée, non seulement quand je la transmets, mais quand je l'utilise. C'est ça qui est très différent, c'est quand je l'utilise, je peux vraiment appliquer ces mécanismes de gouvernance que tu que tu décris en fait, et qui peuvent être qui peuvent être liés à la blockchain. Mais si je n'ai pas cette capacité-là de garder complètement le contrôle sur ma donnée et que j'ai oublié de la copier, c'est du vent.

Meriyem : Et comment ça pourrait améliorer la transparence et la traçabilité des données qui sont utilisées pour l'IA ?

Jonathan Passerat : Justement, par exemple parce que si, si, ma donnée est référencée sur la blockchain, c'est juste un identifiant pas ma donnée exacte, je sais que monsieur X en fait a telle donnée qui est disponible. A chaque fois que je vais donner l'accès à quelqu'un, finalement, je vais accepter son calcul sur ma donnée et du coup, vu que je n'aurai pas copié en fait la donnée, ce que je vais faire, c'est que je vais pouvoir garder une trace très claire dans la blockchain qui va dire à telle heure, tel jour, tel compte à demander à accéder à cette donnée-là. Et je lui ai donné accès. Mais je ne vais pas juste donner accès. Il fait ce qu'il veut. Je lui ai donné accès via ce programme-là qui fait exactement ça. Ou potentiellement, on a fait un audit sur ce programme et on est d'accord avec ce qu'il fait et c'est tout. Et à la fin, à la fin de l'exécution, il n'a plus accès, en fait, parce qu'il a soit

envoyé son programme sur mon infrastructure et du coup, après, je ne lui permets pas d'aller plus loin. Soit je réencrypte ma donnée d'une autre manière si je n'ai vraiment pas confiance. Et dans ce cas-là bah, la donnée est différente de ce à quoi lui a eu accès. Donc vraiment, je pense qu'on peut arriver à des choses assez élaborées, en fait, en termes de gouvernance.

Meriyem : Si maintenant une IA prend une décision, si elle est encryptée, à l'aide de la technologie blockchain, on va dire on va pouvoir peu-être retracer justement les décisions qui ont été prises et les étapes que l'IA a faites. Est-ce vraiment quelque chose de possible ?

Jonathan Passerat : Ca dépend. Si ça veut dire que l'IA est sur blockchain, je ne pense pas que ça soit possible à l'heure actuelle. Si on veut faire de la vraie traçabilité je pense qu'on pourrait, si on sait exactement, quand tu as un modèle d'IA, tu vas pouvoir lui demander des tâches très précises. Tu vas l'entraîner pour faire quelque chose. Tu vas dire, je te montre une image, dis-moi ce que c'est, c'est un chat, c'est un concombre. Des choses comme ça, en fait. Donc, si tu as un système complètement intégré sur la blockchain, qui dit bah. J'ai fait une action. C'est un événement, c'est une transaction sur la blockchain. C'était quoi mon action ? C'était demander une information à l'IA OK. L'IA, elle me dit quoi ? C'est quoi sa réponse ? C'est loguer aussi sur la blockchain. Qu'est-ce que moi j'ai fait avec cette information ? Est-ce que je peux le loguer sur la blockchain ? C'est comme ça que tu peux avoir cette traçabilité, en fait je pense. Et ça effectivement, ce n'est pas incompatible. Il y a des papiers assez marrant où tu as l'IA qui elle-même et dans un smart contracts, par exemple sur une blockchain publique, je pense pas que tu puisses faire ça parce que tu vas avoir des notions d'IP qui vont entrer en jeu ou si tu as des IA qui sont très compétentes que tu ne peux pas divulguer, tu ne vas pas forcément les mettre à disposition sur une chaîne publique, en fait, comme ça, pas en clair on va dire.

Meriyem : Et ça, ça pourrait aider potentiellement de répondre au problème de savoir qui est responsable si quelque chose arrive ou de donner une explication à cette décision qui a été prise parce que l'algorithme a raté à cet endroit-là, grâce au registre derrière ou ça peut ne pas aider à répondre à cette question de gouvernance ?

Jonathan Passerat : Je pense que pour répondre à la question de traçabilité, ça pourrait aider. Mais d'un point de vue de haut niveau, on saurait quel algorithme qui a pris cette décision et a répondu ça. Maintenant, est ce qu'on peut mélanger toutes les thématiques de l'explicabilité des décisions de l'IA, c'est un domaine un peu connexe. Je ne suis pas expert dans ça donc j'ai du mal à voir si ça pourrait aussi être combiné avec la blockchain, est ce que tu pourras finalement ouvrir la boîte noire de l'IA et dire Bah, non seulement j'ai accédé au modèle, mais en plus, je sais que le modèle a fait ça, ça et ça et ça comme décision pour arriver à son résultat. Si c'est le cas, oui, du coup. On pourrait juste en fait descendre d'un niveau de zoom et ouvrir la boîte.

Meriyem : Comment l'utilisation de la blockchain pourrait améliorer la confiance des utilisateurs envers les l'IA ?

Jonathan Passerat : Je ne sais pas, ça dépend. Ça veut dire quoi faire confiance ?

Meriyem : C'est par exemple si un médecin, un individu, un jour il va utiliser une machine

qui fait un diagnostic et il va faire confiance au diagnostic. Et le patient va faire confiance dans la décision qui a été prise également. Par exemple, si la machine dit ah oui, vous avez un cancer, ils vont croire et faire confiance. Selon les études qui ont été menées, il y a vraiment un manque de confiance dans l'intelligence artificielle qui fait que ça peut freiner son développement.

Jonathan Passerat : J'ai du mal à voir pourquoi la blockchain amènerait quelque chose en ce côté-là. Je pense que les techniques d'explicability de l'IA auront un impact plus significatif dans ce domaine-là. Si on comprend mieux pourquoi l'IA prend telle ou telle décision. Je pense que ça sera beaucoup plus puissant que de coupler ça avec une blockchain.

Meriyem : Donc, selon vous, ça n'amènera pas la confiance ?

Jonathan Passerat : Oui, je ne pense pas que ça soit la clé pour amener plus de confiance dans l'IA. On va dire que ça peut permettre d'amener de la confiance de manière indirecte si on arrive grâce à une infrastructure de blockchain, à créer par exemple une économie de la donnée ou du coup, on arrive à accéder à des données auxquelles on n'avait pas accès avant. Et par conséquent, on devrait avoir des modèles moins biaisés, plus génériques si on arrive à avoir accès à des sources de données plus variées, mais ça reste une affaire indirecte.

Meriyem : On peut parler alors justement de la discrimination et des biais. Alors justement, à ce moment-là, vous venez d'en parler on peut diminuer ces derniers ?

Jonathan Passerat : Oui, je pense que voilà, à l'heure actuelle, le problème, c'est qu'une intelligence artificielle ne fait qu'apprendre ce qu'on lui donne, en fait. Donc, si on ne lui donne pas les exemples de tout, forcément elle ne saura pas, elle ne saura pas prédire si elle n'a pas vu ces données là avant. Moi, je pense que les techniques de privacy ont plus d'impact dans ce domaine-là parce que souvent, les populations qui sont sous représentées, que ce soit inégalités raciales, financières ou autres, c'est eux qui ont le plus à perdre à donner leurs données dans le clair. Parce qu'après, il peut y avoir d'autres discriminations. Encore plus si on sait qu'ils ont tel ou tel aspect d'un profil génétique ou je ne sais quoi. Donc, je pense que c'est plutôt la confidentialité. Le fait que les données puissent rester maintenant encryptées pour qu'on entraîne des intelligences artificielles, qui va aider en fait, à lever, à réduire les biais. Plutôt que la blockchain.

Meriyem : Donc, de nouveau, pas la blockchain.

Jonathan Passerat : Je ne suis pas un grand fan de la blockchain. Je pense que c'est un bon outil, mais vraiment, j'ai du mal à le voir, en tout cas dans la santé, je ne pense pas que c'est un outil qui puisse se suffire à lui-même. Ça peut aider en combinaison avec d'autres outils comme la cryptographie avancée. Mais la blockchain, seule pour la santé, j'ai du mal.

Meriyem : Donc, ça ne peut pas augmenter non plus la quantité de datas qui sont accessibles et la proximité de ces datas ? Je lisais que ça pouvait retirer aussi le pouvoir des grosses entreprises et le mettre dans la main des patients qui, eux, vont avoir accès à leurs datas. Savoir où vont leur data ou, pour quel type d'utilisation, etc. Et par exemple, eux donner accès à leur datas et monétiser ces datas.

Jonathan Passerat : Ouais, mais j'entends ça, mais pourquoi j'ai besoin de Blockchain pour faire ça ? Si vraiment c'était possible? D'ailleurs, ça existe à l'heure actuelle. À l'heure actuelle, tu peux te faire contacter pour participer à un essai clinique et être payé en fonction si tu donnes tes données. Et tu n'as pas besoin de blockchain pour ça. Donc, pour moi, ça, c'est marginal en fait, ce que ça apporterait dans ce domaine-là.

Meriyem : Au final sur les points qui ont été abordés ici, vous ne voyez pas vraiment la convergence des deux alors ?

Jonathan Passerat : Je ne la vois vraiment, pas pour le très court terme, mais je le vois si on arrive à mettre en place des choses assez complexes, comme je l'ai dit en fait, si on arrive à mettre en place de la gouvernance, ça, j'y crois. Mais pas forcément au niveau que de la donnée. En fait, je pense qu'on va arriver à mettre en place de la gouvernance de modèle d'IA aussi. De la monétisation, peut-être. Mais ça, ça ne passera pas que par la blockchain. Pour moi, c'est la combinaison de la blockchain, oui, mais c'est peut-être 20% de blockchain et 80% de cryptographie.

Meriyem : Pour passer au TAM model, est ce que l'intégration des deux systèmes va augmenter la performance de l'IA et de la blockchain ?

Jonathan Passerat : Peut-être pas tout de suite, j'espère, mais pas immédiatement. Pas à pas avec ce qui est sur le marché à l'heure actuelle.

Meriyem : Dans un futur lointain ?

Jonathan Passerat : Oui, et qu'on essaie de construire à consensys health. C'est important de dire ça.

Meriyem : Est-ce que ça vous semble facile d'implémenter ça ?

Jonathan Passerat : C'est difficile. C'est difficile et c'est difficile pour deux raisons. Il y a les défis techniques, mais il y a des difficultés d'adoption par les utilisateurs aussi. Et ça, c'est peut-être encore plus difficile je pense parce que si tu regardes à l'heure actuelle, même envoyer des bitcoins à quelqu'un, c'est laborieux. Ce n'est pas un truc que tu fais comme ça. Donc, ta grand-mère ne peut pas le faire.

Meriyem : Donc il faudrait augmenter l'éducation de la population envers ces technologies ?

Jonathan Passerat : L'éducation et la couche de présentation aussi, comment on l'expose

Meriyem : Est ce que l'utilisation de la blockchain est compréhensible et clair ?

Jonathan Passerat : Non, non. Je pense qu'il y a beaucoup de bruit autour de ça parce qu'effectivement, ces deux techniques sont assez hype. Je t'envoie des articles qui parlent un peu de cette convergence, de ce qui existe au cas où tu ne les a pas vus encore.

Meriyem : Est-ce que les bénéfices vont surpasser les coûts ?

Jonathan Passerat : Moi, je pense qu'à très long terme, oui, parce que on commence à voir un peu la fait avec tout ce qu'on appelle la gig economy, je pense qu'on va aller de plus en plus vers ça. En fait, des carrières où on est sur un emploi ou une entreprise pendant 40 ans, mais plutôt en fait, on va se retrouver avec plein de sources de revenus et en fait, ce decentralized marketplaces de data, de modèle elles vont faire partie de ces sources de revenus. Donc je pense que oui, à terme, il y a un vrai bénéfice dans cette direction, mais ce n'est pas simple.

Meriyem : Et qu'elle est votre ressenti par rapport à l'implémentation de ces deux technologies ?

Jonathan Passerat : Je pense qu'on a les techniques ou du moins en fait, je pense qu'on a au moins une première version de tous les éléments techniques dont on a besoin. Maintenant, ça va prendre du temps de les polish pour bien les mettre ensemble et que ça soit quelque chose qui ai du sens en fait. Mais on n'est pas dans le domaine, tu vois par exemple de est-ce-qu'on va arriver à faire de la fusion nucléaire ? Non, je pense qu'on a les éléments. A nous de les améliorer. Mais je pense, quand on connaît les techniques à utilisées pour le faire.

Meriyem : Et après, est ce qu'il y a un potentiel dans le futur, quelle est votre attitude par rapport à ça ?

Jonathan Passerat : Totalement. Moi à l'heure actuelle, je refuse en fait d'utiliser des services qui ne respectent pas la privacy mes données. Et si demain on a ses garanties là, je serais ravi, par exemple. Parce qu'en fait, à l'heure actuelle, on est sûr de la médecine très, très générique en fait. Alors que si chaque patient avait une analyse très précise de son génome, qu'on savait quel potentiel de maladie tu vas avoir, qu'on pourrait anticiper en fait des traitements au lieu de le faire quand les symptômes apparaissent, parce qu'on sait que tu as tel ou tel risque ou que tu as tel ou tel antécédent familial ou autre. Ça serait génial et on aurait un gain énorme pour toute la société. À l'heure actuelle, ça veut dire donner ton génome à une autre entreprise qui contrôle, qui va le revendre à des boîtes de pharma sans ton consentement ? C'est déjà arrivé, hein ? Ce n'est pas de la science-fiction et surtout encore plus en fait, quand tu réfléchis. Pour moi, les données génétiques, c'est vraiment le truc ultime. Parce que parce que c'est des données qui sont hypers paradoxales. Quand tu donnes tes données génétiques, tu impliques ta famille. Si, tu décides de donner tes données, ils ont la moitié de l'ADN de ta mère et la moitié l'ADN de ton père est arrivé et ils n'ont rien demandé pour ça. Du coup, c'est terrible. Si on n'a pas vraiment de solutions de data privacy pour ces traitements-là, on a un vrai problème. On a un vrai problème de société, en fait. Et quand on arrive à le résoudre, à mon avis, on va aller plus loin. Ouais, j'ai hâte qu'on arrive à faire ça de manière normale, à l'échelle et que ce soit hyper intégré dans la société.

Meriyem : Mais dernière question quand on voit sur Internet la blockchain, elle permet justement d'avoir cette privacy et d'être anonyme, entre guillemets. Donc, pourquoi ne pas donner accès à nos données avec cette anonymity et privacy.

Jonathan Passerat : Mais je pense qu'il y a beaucoup de bruit sur Internet. Les données anonymes, c'est ce qui a été pas mal étudié, en fait, ça ne marche pas. En gros, les données anonymes, c'est juste une manière de donner un peu de confiance. Mais on a énormément

d'études qui ont été faites, en gros, même des données anonymisées, on arrive à les identifier en les retrouvant avec d'autres sources. Et en fait, à l'heure actuelle, si on commence à accentuer ce phénomène, à partager toujours plus de données anonymisées qu'on va pouvoir recouper avec les réseaux sociaux, les choses comme ça, on se tire une balle dans le pied parce que ce qu'on va faire, c'est créer encore plus de problèmes et de fuites de données. En fait, je pense qu'il est vraiment temps de dire stop aux données anonymisées. On sait faire mieux maintenant. Il y a des idées techniques, qui sont bien supérieures et qui donnent des garanties bien meilleures à l'anonymisation de données. Et il est temps de dire stop au partage de données en clair. Et je pense que si on prend cette décision là, ce n'est pas évident, mais on va avancer encore plus dans le domaine de la santé.

Meriyem : D'accord, merci beaucoup pour toutes ces informations.

Jonathan Passerat Avec plaisir, n'hésites pas à me recontacter si tu as une question ou autre, tu dois le rendre quand ?

Meriyem : Le 15 décembre.

Jonathan Passerat : Ah ben parfait, si on doit refaire un call, n'hésites pas.

Meriyem : D'accord, c'est super gentil, si j'ai besoin d'éclaircir quelque chose, je vous contacterai. Encore un grand merci. Bonne journée à toi.

Jonathan Passerat : A toi aussi au revoir.

Interview Tim Richmond

Meriyem : Hi, how are you?

Tim Richmond : Good, thank you very much.

Meriyem : Thank you for joining the call. I will present myself quickly. My name is Meriyem and I am a second year master student in Business Engineering, in Belgium. And I am finishing my master with a thesis about how blockchain can impact AI. How the trustworthy technology of blockchain can positively impact AI: exploratory research for technological and ethical aspect in healthcare. Could you introduce yourself, your relation with blockchain and AI as well as with healthcare?

Tim Richmond : I have 25 years' enterprise level experience within technology, and I've always tried to focus on technology which is beneficial to humanity in some ways. I have been involved in accounting in the past, which is obviously maybe not quite so beneficial on the whole, but I mean, I've focused on things like using technology to reduce the impact on the environment of large organizations by analysing data to look for energy reduction projects, that kind of thing. So I've always been a singularitarian, and I've always had a concept of the progression of technology and where we ultimately can lead. And also, I noticed that humans have a real difficulty with understanding exponential growth. And when they project the future, they tend to neglect the concept of solutions that we are not yet aware of. So, for example, when looking at the environment, you know, it's clear that we need to be better at managing, how we treat the environment. But when they make these projections going forward, they do not take into account emerging technologies. So it's easy to look at the current state of affairs and then use that as your basis to project forward. But when you look at the emerging technologies like fusion power, artificial trees and then, what's recently come to the forefront is the concept of using decentralization and automation as a way to deal with a lot of the things that perhaps we wanted to reorganize but couldn't because of economics or because of the way in which the current financial paradigm is sorted out. So there's a DAO, decentralized, autonomous organization. Basically a decentralized autonomous organization focusing on trees and forests and deforesting means that you can create a balance for nature whereby it costs more to fail too many trees. It has really anything to do with healthcare. But it's emerging technology. But the key thing really is data. That's the crux of everything, right? It's ok having islands of data everywhere, but you're only going to get a small picture of or statistically, you can come up with a statistical model based upon a small data set. But if you're excluding wider data, then that model might be completely incorrect. Now, one of the frustrations that data scientists have in general is bias in data. I'm not talking necessarily about human bias, although that is obviously a factor. I'm talking more along the lines of systemic bias. So what I mean by that is that by building the model yourself, you are not by nature, you're already placing restrictions on the model. And so therefore there is always a natural bias. So how do we get around this? And it's a major problem. Blockchain and decentralization seems to be the key to this because it has to seemingly oxymoronic, it is a good word. It has two seemingly different properties which actually work together really well. And the first thing is that blockchain is immutable. So it's permanent and it's traceable. So you can trace every piece of data that flies around there. But it is also anonymous in the sense that you can anonymize data. In a way which means

that it's private, to a degree, in terms of it's not directly linked to you. So why is this important for health care? Well, it's super important for health care because to create systems that are able to assist AI systems, that are able to assist medicine, we need data. And the only way to get that data is from the ground, from the people. And medical data is obviously one of the most closely guarded personal data that you produce in your life.

So covid is kind of like a really interesting time. I do not like using positive words to speak about covid because obviously it's horrific. But we shouldn't ignore the positive things that happen as a result of negative events, right? And so what's happened is, it's given the ability and shown and come to the forefront, the need for pulling together all of this data and the backlash that's come certainly from the UK and I'm sure all around the world when their governments have been creating apps for your smartphone that track your location, that, you know, in some cases track even your heart rate, you know, these kinds of things. Where's that data going? Centralized. That's what people are worried about, they're worried about having the information. I think people want and understand the need to help them, but they do not want their data to be used against them in some way. So trust is a major factor. But if you have a blockchain based system, a decentralized system where your data is anonymized effectively. You're able to add value to the overall data set and get over the whole centralized control system. Covid has brought this to the forefront. But it's not just for covid. And Singularity has a spinoff company called Regiu, an app, which hasn't been launched, this is close to launch. And what it does is it tokenized, monetized your personal data. Basically what it does is it takes your sensory data, and then feed that into an A.I. model and that A.I. model basically feeds it back to you. It looks like your pre disease by predictive modelling. Please seek medical help for this or please increase your sleep pattern by X, as our predictive model suggests, this would circumnavigate this illness. But it also allows them to tokenized their data. So in other words, there's a business model behind it as well, which means that they earn tokens for feeding their data into this model. So it's kind of like a win win, really, because obviously they're getting the benefit of A.I. assisted health care, but also they're being rewarded for adding that data into increasing the quality of the model. So, yeah, I've talked for quite a while, I hope I've answered.

Meriyem : Yes but it is clear. And it's kind of a niche market that you are talking about right? With your spin off of singularity. Because I haven't found, like, real concrete example about blockchain especially in the health care sector.

Tim Richmond : Yeah. There's a few things that we're working on that are directly to do with healthcare. So Singularity Net ultimately is a platform where A.I algorithms can interconnect them and be shared across the world. There's a marketplace which is kind of like the shop front of that. But ultimately that the main part of it is the interconnection of AI. So the benefit of this is just that you can have different AI working together. So you might have an AI which has been trained to listen and give you an analysis or your voice and give you an analysis on that. And you might have another AI which has been trained on, I do not know, maybe vision recognition or because this is something else. Right. So machines are getting better and better and better at these different things. But if you can interconnect multiple models together, you can create services that the original A.I. wasn't designed for. Now, so, what we just want I do not know whether you saw that, but in conjunction with Hanson Robotics, who are behind Sophia, the robot we're working with Connected Living, which is a large technology organization in the US who have the license

to deliver technology into care facilities in America. And we're working to create an AI assistive robots to help within the health care sector. So this is another way to monitor and, you know, during pandemics and things like that, obviously, you've got the people who are nursing, who are actually delivering the care. There are high risks. The patients are at high risk. So having some kind of a device which isn't just a box that has the ability to make some kind of a connection with the people, that they're communicating with, but also give all of the advantages of, you know, monitoring, gaining the data on the patients, giving the patients back the kind of care that they need, allowing the patients to I mean, if you've got sort of a patients, I do not know with early Alzheimer's or something like that, you know, they're just absent mindedness, to be able to ask rather than go, hey, Google, you know, and a question which is not personalized, the interaction will be two ways that they will be telling them something about themselves and then that robot or A.I. assistant would get to know that individual and be able to communicate back. So you know, you forgot to take your pills or do not take your pills or you've already taken them or, you know, what's the name of my second cousin, son, you know, this kind of thing. Right. So it's more sort of a motive. So from that side, you know, there's a lot going on as well. On the SingularityNet itself, there's a bunch of algorithms already. One of which is quite interesting is that there's a gene annotation service. So this is as you know, the human DNA is a tremendous, massive amount of data. And so understanding the relationship of genes to express particular behaviours from a biological standing. Well in 2001 when we decoded the human DNA, it was just like opening up a massive bolt of information, but nobody knew how it was all connected. And so gene annotation is the real thing that's already out there in the world. It's not special to us. But AI gene annotation is learning constantly about the relationships of different genes and how one gene might have a different relationship with many of the genes and how then you can use that data to make predictive models about, you know, what somebody might experience later on in life in terms of disease. So it's looking like these kinds of models will be able to maybe some people won't want to know. I mean, I would want to know, right? Some people might not want to know, but it might be possible very soon to be able to take someone's DNA sample. Someone's. DNA and AI will actually predict these of the diseases of old age that you will experience, these are the steps that you need to take now to avoid them. So this is the other side of it. The key to it all is decentralisation. It doesn't necessarily have to be blockchain, you know, I mean, 10 years ago, it was already quite difficult to be a futurist because emergence was already there. But now it's becoming really difficult because emerging technologies are appearing so fast that it's not quite possible to predict, you can take a technology and see where that's going to lead you. But in a year's time, there could be another technology which is emerged from the existing technology, which is better. But you didn't know about anyway. We're already beyond the event horizon of the technological singularity is the way that I see it. Right. So we're already accelerating faster than our ability to really manage. And, you know, I think Mark Zuckerberg, you know, congress his time in Congress, you know, a couple of years by now. But still, I think that was very a very telling moment because, you know, we had a group of people who are supposedly in charge of governmental structures, having no concept of, you know, social media, really. So, yes, AI is then going to come into decision making at a higher level because of the changes, especially when it comes down to things like health care. So we've got lockdown's happening all over the world, right? In the UK, we just announced a new lockdown. I understand why they've done it. I do not agree that they should have done it. My personal view, because I think that they're discounting the effects of the lockdown itself. So I think that I can't blame them. I'm not blaming them because they're in an

impossible situation. And, you know what I'm saying is that the data is so complex, the level of complexity is just so massive that it's not possible for them to be able to analyse it all and choose the correct outcome. They can't think far enough ahead. AI would help in this respect tremendously because it is perfectly suited to be able to take disparate, so seemingly unconnected data sets, bring them together and create projects on many different scenarios. So I do not think it will be AI making the decisions directly, but I think it will be AI within governmental structures that's able to take in all of the data and then give a bunch of options, of which then the humans will choose the best outcome for whatever they want. That's not in place right now. It needs to be. And I think that it's becoming increasingly more obvious that's needed.

Meriyem : Yeah, it's really interesting. I think I already have all the answers I was looking for. I have some questions already. Normally I have some question to go through, but it's really great because you already answered some of them. I have a question about some things that you already have said. About the fact that if I understand correctly, that the algorithms are able to take like the decision from several different algorithms. Is it related with the joint decision? I was reading that blockchain can help with making joint decisions is it related to what you are saying?

Tim Richmond : OK, so how decision making works within something like a DAO. There's usually a consensus. Within something like SingularityNet, one of the major obstacles to overcome is the ontology of the algorithm itself. What you should be able to do is in natural language, say I would like, it is a media example, but you can translate it, I'm sure. So I should be able to say natural language, I want to translate this person's from French to English in this video. So behind the scenes, what should happen is it's a swarm of AI would need to interconnect to be able to achieve this. So you would need an AI which can transcript. So voice to text, you need a translation that can text, you know, create the text translation, then you need another AI which can re modulate back to voice and then you need another AI, which can then identify when that person's speaking and insert and then another one that maybe can we modulate the lips of the person. Right. So you've got a bunch of AI there. So how does that work. How did the AI know what each other does and how do they communicate effectively with each other? This problem is not solved yet. So we're halfway there with the API. So the interconnects, the point that these two things can connect and then it becomes a question of the decision making process. At the moment it is a higher level thing. So at the moment, what we're looking at is creating an AGI, which is an artificial general intelligence. And so AI at the moment is what's called narrow A.I. So that means that it basically can learn, so is a machine using machine learning to learn and it can create, there are wrong ways that you can set by learning very slowly and not very efficient, although because of the speed of computation, it seems very quick from our point of view. But actually it isn't very efficient. And so it's possible to do that. And then but there needs to be a higher, more abstract reasoning layer of both this and that we believe is achieved by complexity. So increasing the number of algorithms that can interconnect and then giving them a task and then it would need to be some kind of translation. But if you think about our own minds, right, we have a subconscious mind and neurologists tell us that actually there is no free will because our subconscious mind is already made that decision before we're even aware of what it is. And then it travels down into the awareness and from there down into the motor cortex to where we actually make a move. Right. So AI decision making is a bit like that, right, on a higher level. You can create an AI which can make a decision based upon a set of rules which you put in place.

But still you're ultimately giving it the rules set. Right. So however Alfa go, I'm not sure you're aware of Alfa Go. Alpha go zero. So Alpha Go is obviously a very complex game like chess, but it's an Asian game. And the reason why it was so complex, actually it's not like chess, if you imagine chess as a tree and you have all these branches of all these moves that could be made. Chess has a limited set, still very large, but a limited set moves so computationally it's possible to create an AI which can go through every iteration of every move and choose the one which is best. Right. You can't do that with a game like go, you can't do that with a game like go because the tree is so huge, the branches are so wide it's impossible for an A.I. to go through every iteration. So what needs to happen is it needs to have like a more abstract reasoning centre which can ultimately create strategies. And the way that they did this to create this was to create an AI which played itself. And then each game, obviously, it learned from the previous game. But it kept ratcheting up because it kept playing itself. It kept ratcheting up because of the speed of the iterations. The games were lasting no more than a few seconds per game. It was possible to create an A.I. which formed its own strategies. OK, now this is basically the height of a machine learning and where it can go, right. So if you look in nature and nature always moves, always chooses a solution which uses the least amount of energy. It doesn't force anything, right, so it naturally moves to the least resistance. So I think that we've got a bunch of different ways of doing this. At the moment, blockchain and decentralization gives us the ability to bring in different AI, from different places and all interconnected. So hopefully the learning that it made in terms of decision making can be translated to autonomous cars, for example. There's some level of decision making learning that has happened in this algorithm that could be valuable to an AI which is driving a car. Maybe it needs to strategize about the position that is on the road. And so blockchain gives the ability for these different models to connect to each other. Well, until we get to this higher level reasoning, decision making is always only limited to the certain data set and a certain level of learning with that particular algorithm.

Meriyem : And how will it work? How is it working to take a joint decision between these two algorithms, thanks to blockchain?

Tim Richmond : It sounds like a complex thing, but it's super simple. It's all about the transaction. So what you're doing is that you're transacting between two systems. Why blockchain is important is that it is a system which both parties can understand. So if you think about our monetary system and how transactions work, there's a translation, there's different currencies, translation to this currency, different rates or tariffs, all these different things that are happening. But with blockchain, it's just direct. So what you're doing is you're creating a handshake between these algorithms. If you imagine an algorithm which has a data set which monitors the breathing of babies and does some other algorithms over there, which has a vision recognition which can time-lapse to see the breathing of babies. So what you can do is you can connect those systems together using an API, right. So the two connect and then you code your own program. Right. So this is already something which we've done with a music app. So we've leveraged an application from the platform, incorporated it into an application. This application strips audio of voice from a song. Right. So the coder basically creates an application and then draws in these different AI by API and then that's how they interconnect. So it isn't a case, like I say, we haven't got to this abstract reasoning where we can say, I would like this because ontology of A.I. means that they basically would have to understand what they do, in relation to what was requested and understand the same for other A.I. algorithms

and then decide which one they want to connect with. That's a separate thing which doesn't exist yet. But at the moment, so if I wanted to create this algorithm that monitors a baby, I could create a camera webcam or a baby monitor, which leverages the blockchain to bring in services from these different algorithms to deliver the service that I want. Right. That's how it works at the moment. So that's where the blockchain really has value. It's transactional, blockchain is the protocol of data. Blockchain is the protocol, the transactions. So, it allows you to make purchases directly from the connections, directly from the AI itself, the data that's coming to and from it, it is probably being transmitted over IP. Right. So it's not it's not specifically necessarily blockchain, but the smart contract. The blockchain obviously runs by having like on Ethereum, for example, the smart contract so you can you can create your own rules set for these transactions. So you can do some quite clever things actually. Ethereum has the ability to become a computer itself. if you created a bunch of stuff, the crux of it, is that decentralization allows data to be brought into modules and interconnected models. it's like everything else, you know, next year there might be some new technologies that nobody knew about. And, you know, it's not possible to know everything.

Meriyem : And, how would you define blockchain?

Tim Richmond : Very simply, if you imagine different kinds of networks. OK, so IP, Internet protocol is the protocol for interchanging information. Blockchain essentially is a protocol for interchanging transactions, and it does this in a decentralized way. So ultimately it's known as a distributed ledger, although there are quite a few people who question this. Personally, I like to define it as a distributed ledger. So essentially it's like a spreadsheet whereby the blocks in the blockchain are actually just like the lines on a spreadsheet. You know, you have a situation where every time a transaction happens, a block is added to the blockchain. And how it's distributed essentially is that this ledger is distributed across many nodes, computers around the world in a cryptographic way. And this is what crypto means, right? Cryptography. It's essentially a highly complex algorithm, depending on which blockchain it is working. But obviously the algorithms are different. But ultimately it generates a hash. So it generates a code which encrypts that transaction and that's for the transaction to complete, it then requires decrypting. And this is what the miners do. You heard of miners. Miners essentially are the people that hold the ledgers and they're all over the world. And so when you submit a transaction to Ethereum, what you're doing is that you have what is called a gas price. And this is additional cost on top of the transaction that you're willing to give the miners to fulfil that transaction. So the miners earn and this is why they are mining. They earn crypto from the transaction itself by processing the transaction. That takes a great deal amount of computing power, depending on which blockchain. Obviously, at the very beginning, it was quite easy to mine Bitcoin. It was very, very easy to mine. You could actually mine Bitcoin with the laptop. When it first started, it was quite easy. But now, because of the fact that the complexity of the hash itself has increased, it's now requiring vast amount of power to decrypt. So in a nutshell, to encapsulate it all, blockchain is a decentralized way in which transactions can happen in a way which requires no centralized body. So if you pay for a bill in your everyday life, what's happened there is you've gone to work. You've earned your money. The money has been transferred into your bank. When you want to pay the bill, you go to the bank. It comes out of your bank account. So ultimately, a centralized system is not needed in the blockchain. You have a wallet. The person you're buying from

has a wallet and you're just transacting securely between those two sites. What's in the middle is the blockchain.

Meriyem : And you were talking about miners and big computational power. Do we have miners for every blockchain? For example, while talking with other professionals, they were giving the example of I am a patient and there is a doctor and we are sharing information. Who is the miners in that case?

Tim Richmond : So actually the miner in some circumstances. There are blockchains which are minerless and in fact the process of having a minor is what slows down the blockchain. Blockchain is very slow. It's slow for many reasons, slow because it requires a wait for compute time, a miner to pick up the transaction. Slow because the computational power required to process that is slow because the volume of transactions at any one time can be more than the computational power available. So it slows it down and it's actually a solution. There are a number of solutions which look to get around this, such as hash graph, which is a way in which you can manage a transaction without Miners effectively. It's a different way of distributing the network. There's also SingularityNet you also looked at Todor networks, Todor Networks also have a mindless environment. The advantages, it's a lot faster to do it that way. The disadvantage is the moment you remove the miners, you always have to reduce the number of possible nodes and therefore you're increasing the amount of centralization within the system. So it's like a balance. What's going to happen in the future is we're going to have quantum computation. So quantum computing and also quantum cryptography. So they are two very different things. Quantum computing basically is a way in which standard computers use bits. So that can be ones and zeros. Quantum computers actually use a qubit, which is expanding its computational power massively. It's not a magic pill to all computation. Quantum computers are very good at certain things, essentially going through massive amounts of data in a very short period of time. It's a nightmare for security and cryptography in general. Once we get to a certain level within quantum computing, it means that our security algorithms become obsolete. Which is quite dangerous situation to be in. So this could affect crypto in quite a big way. So the way in which blockchain works now is going to be forced to change, along with all of the computational based security systems. So Quantum cryptography, on the other hand, is a way in which you are able to send data using fundamental laws of physics to encrypt data. Basically it uses something called entanglement. Which is a physics term. Essentially Einstein called it spooky action at a distance. Because essentially what they're able to do is if you take a photon of light and you split it by a two-way mirror, what happens? The energy state changes. It basically splits the energy state down the middle. So you've got two photons, exactly half the energy state of the original photon, and you send one down a piece of fibre and you send the other one down a piece of fibre. And so you would think that due to the laws of nature, that if you look at one right, it would have no effect on the other. But that's not true. What we find is that due to this term quantum entanglement, if you look at the spin of one photon, it actually affects the other photon and the other photon responds and spins in the opposite direction to the one that you've got. So there's a whole bunch of physics behind this. And I know quite a bit about quantum mechanics, but I won't go down that road. But the ultimate way in which this works is that they're able to take a communication and encode it. And the beauty behind it is that the infrastructure to do this already exists because most of the communications networks are already fibre. So they're able to send the data down using quantum cryptography. And it means that if anybody eavesdrops,

anybody intercepts, the message it scrambles. And so it's majorly secure. But what it does is it removes the need to encode the data at the beginning and decrypt it at the other end, which is a massive overhaul on the way in which we transmit data and the amount of energy. It's incredible, actually, the amount of energy that's required to encode data to a significant standard to send it securely. It is tremendous because you need powerful computers to encrypt it. But with quantum cryptography, you do not need any of that because you're using a law of nature as opposed to actually wrapping it in very complex algorithm of code. So to answer your question, yes, it's going to be possible to have minerless blockchain, and that's the way that it's going to have to go in the future for the simple reason that we need speed and we need to deal with the possibility of the way in which we encrypt code being decoded by quantum computers.

Meriyem : And you already talked about some of the benefits. But do you have any other benefits that the blockchain provides according to you?

Tim Richmond : Yeah, blockchain, cryptography in general and the way in which humans use crypto. It's a very exciting thing. But actually, if you look at the way in which blockchains are designed, they're really designed for communication between machines so that the major benefit of decentralization within the blockchain and blockchain style transactions is that it facilitates an environment where machines can transact between themselves. And this is going to be very important in the future for automation. So imagine a future whereby we've automated every part of a supply chain. Take paper, we've automated the selling of the trees, the logistics of getting the wood to the factory, the factories automated, the logistics of getting the paper, the output, the paper to the customer is automated, so it makes sense to have a machine style transaction system so that all of that can happen automatically. If you were to do that via centralized methods with money, it would be far slower. And also it would be subject to variations in the monetary system that exists. So if everybody is transacting globally using Ethereum, you might be buying paper from Company B in Germany. And the currencies are totally different. The way in the banks would probably have to go through three or four different banks before that. It's a nightmare. Whereas if both of them are transacting on the blockchain, it is direct. Although it's decentralized, it's still a direct interaction between customer.

Meriyem : And, there is different types of blockchain, and in the literature review there were some people saying that a private blockchain would be better in the healthcare sector and others were saying that blockchain would better suit. Which one do you think is better, according to you?

Tim Richmond : OK, so there's actually a case for both to exist together. So the fact that a lot of higher businesses are already employing their own blockchain to so large conglomerates that have businesses all over the world often installed things like what's called NPLS network. OK, an NPLS network is a Cisco infrastructure which large businesses, global businesses can install, which is essentially their own private network. And they do this because they want security within and control over their own network without leakage and speed. And so although blockchain does not offer speed in the same sense, where speed is not an issue, blockchain is a far cheaper route to delivering this because the cost of rolling out an NPLS network is massive. I mean, it's huge. So a lot of large corporate businesses are looking at employing their own blockchain infrastructure

to be able to achieve this same level of internal security. For health care specifically, you've got two types of requirements here. You've got the need to secure privacy, I think is the primary key. And then there's the need for access to data. So what blockchain does is it enables you, although all transactions are entirely immutable so that they're permanent, that you can trace everything. It also has a fantastic ability to anonymize data. So you're able to obtain vast data sets while maintaining someone's privacy. Right. However, obviously it depends on what the use case is. So, for example, if it's for research, you want access to as much data as wider data and deeper data as you can get. Blockchain is ideal for this because it allows the collection of data from sources from people that perhaps wouldn't normally want to give up their data because it allows them to maintain that privacy. However, if there is ever a connection between the person and the data, it is then immutable. So there was recently a whole thing about the right to be forgotten. And GDPR in general, it's a legislation which is out of date before it even came in because you can't remove data from the blockchain. All right. So yeah, so blockchain is also a great way of maintaining data, whereas previously it would have been lost, it is another great advantage. And for that, an internal private blockchain within a hospital environment is a fantastic route to being able to tie together, you know, previously unconnected data in a way which is permanent.

Meriyem : Ok, so now to see the merging between AI and Blockchain. How Blockchain can help to facilitate the accessibility to data that we are going to feed into the machine learning?

Tim Richmond : Well, blockchain and AI, it is like a marriage made in heaven. Right. These two things, they facilitate each other in amazing ways. So I've just mentioned the anonymization of data. So what it is, is that we're getting to a point where I'm sure you've heard of IoT right? So IoT ultimately, where all these devices are connected together, and there are all at the moment not able to really see each other properly, even though they're connected to the Internet. They're not aware of each other. And so where things are going and I know I'm sure you do know about cloud and what cloud is about, but what's going to happen is we're going to have a merging of cloud based style technologies with something called grid computing. And this is going to emerge from IoT. So this is where all devices are interconnected with each other and share resources. So, like, believe it or not, you have a computational chip in your washing machine, right? It has probably an A.I. algorithm which intelligently monitors the data coming from the various sensors to make sure that it doesn't overheat or if it is spinning too fast or if there's a wobble to stabilize, you know, these kinds of things. But it's idle most of the time. Right? So it doesn't actually do anything most of the time. It also has a memory, very, very small. But, you know, maybe a few megabytes of memory in there. But if we could connect, like not just washing machines, this is true of most devices these days. If we could connect everything together via IoT, then all of these devices can share the data into what's called big data and big data is what bubbles out of IoT. And so it is a massive resource of data that previously would be impossible for humans to recognize any kind of relevancy between data sets. AI, on the other hand, is fantastic at being able to see interconnections between different things. So not only will your computational device that you use at home, your laptop, your computer, your phone, not require consistent upgrades of physical hardware because it'll draw in processing from the cloud. So it will pipe in computational power. It'll also be able to share into big data all of the data that's there and blockchain and A.I. obviously, when you get to the point where you've got this massive data set. You need some way for A.I. to be able to

interconnect these devices, to be able to interconnect and blockchain style technology is ideal for facilitating these kinds of transactions. OK, so the data is being ported continuously and consistently. In fact, our annual data that is increasing exponentially in line with the amount of data we produce each year is increasing in line exponentially with our technology. In fact, it's now getting to the point where we're having to really think about how we can store this data in a form that can be recalled. And some people have been looking at various ways of doing that, holographic storage mediums and for long term storage, even biological means like DNA storage. But all of this data basically can be analysed and A.I. is able to find interconnections with data sets that we would never have known. So a good example is a horrific event in the 1980s, was the famine in Ethiopia. It was a dreadful, horrible event. And at the time, everybody thought it was just an act of God, force of nature. Over time, we analyse the data and we found that actually the lack of rain that occurred during that time was caused by a massive increase in particulates in the atmosphere in America and not to blame America, that's just industrialization. But the point is that it's the butterfly effect, the chaos theory of, you know, this thing affects that being affects that thing. And it ultimately has an outcome. AI is going to be able to analyse big data and we're going to be able to make far better decisions based upon these interconnection that we're not able to perceive as humans.

Meriyem : And how can blockchain also help with the transparency and the traceability of data that are going to be fed into the machine? Can it help with transparency as well? I was also reading with liability issue, is it possible to kind of not open the black box, but to see how the machine came up to a decision by tracing back what happened?

Tim Richmond : Absolutely. I mean, this is, again, a major benefit. So as much as anonymization of the source of data is possible, if you want to know the source of the data and you want to know, look, this is me, this is my transaction, it is entirely possible to trace everything that happened on the blockchain. It is entirely immutable. And this comes down to the distributed ledger and the way in which the transactions are added to the block. And then the entire ledger is distributed across many, many things. So you can't delete from that. You can roll back. It is possible to roll back on a blockchain transactions, but even the roll back is immutable. So, you know, everything is entirely there until the whole blockchain is destroyed somehow. But you know, you would have to go around every single computer that has that ledger destroy, that hard drive, which is not done. That is not feasible. So it is perfectly possible in terms of machine learning. And actually, one of the interesting things about machine learning is that it actually teaches us ways in which we didn't even realize it was possible to achieve a goal. And so when machine learning works by iteration, you basically give it a goal and you just let it go. It has some very simple rules. So if it's an avatar with four legs and you give it a goal of getting to B from A and that obviously has inside the avatar, the code so that they can move in X, Y and Z dimensions, but that's it. And then you leave it and it basically goes through iteration. It basically scores itself on how well it's done to achieve. It basically scores itself on how well it's done to achieve the goal. So if the goal is to get to be, how far did it get in this iteration of the algorithm? And so you leave it until it achieves its goal. And then all of the interactive data that it's produced is available. So if you did that on the blockchain, then basically you've created a situation where everything would be immutable. So it would be permanent. I mean, to do this, you can do this on your machine at home. Right. It isn't that computationally complex to create an algorithm to do this. Right. But that would exist on my machine. It wouldn't be everywhere. So it's possible to put machine learning on the

blockchain and entirely trace this. And actually Ethereum is perfectly suited for this because it allows you to create smart contracts, which essentially in their own right can be very complex in terms of what rules they do.

Meriyem : That answers the question. And about the trust improvement, I was reading, especially in the healthcare sector, that the doctors that are going to use the machine that will help with diagnosis, for example, or the patients, they tend to not trust the decision that comes from the machine. How can blockchain helps in some ways to increase that trust?

Tim Richmond : So it's a very funny thing because life is obviously irreplaceable. And I mean, there's the risk of getting a diagnosis wrong anyway. Right. And but what we need to do is we need if you can prove that an algorithm diagnosis, terminal cancer with a 96 percent accuracy rate. That's fantastic. OK, but you can't quantify that four percent that it gets wrong, right? The four percent, it gets wrong. Those people are dead. Right. And that's an unacceptable circumstance. So what it does, what we're able to do is we're able to speed up diagnosis. All of the data needs to be gone through by a human being at all times. But what it allows you to do is say you had, I do not know, a thousand patients. that's an incredible amount of work. But if you're able to run through the algorithm, which then identifies 10 patients, that has a 96 percent accurate diagnosis of cancer, you're able to take those patients and bring them to the front of the queue. Right. And then diagnose those patients first, speeding up the overall process. You still need to go through the nine thousand nine hundred ninety patients. But what you've done is you've been able to identify the urgent cases of the likely urgent cases. So you're not damaging the four percent who perhaps wouldn't have been picked out if we just relied on algorithms. They're still getting diagnosed at the same rate as before, just those that we've identified immediately as being able to be brought to the forefront. And so I know a little bit about this. My father last year suffered quite badly, he had a cancer, bowel cancer, and he had a major operation in 78. He almost died three times. We're super happy that he pulled through. And it's a real testament to how strong he is. But also it's encouraging as well to see how far medicines come in, because if this had happened, you know, even 10 years ago, he'd have been dead for sure. So but in the process of this, he went through various scans and the scans and the data that he had were basically in a massive pile. And we have to wait a long time before they got these scans. So with machine learning, AI and this kind of technology available, they would have been able to have brought his case out quiet, quite quickly and that would have improved his chances of surviving even further. So this is why it's a really, really important thing that this technology gets out there, but the trust element is removed and as a blocker for thinking about how they use technology and more thinking of it as being an aid to speed up the process.

Meriyem : And where a blockchain can intervene here by the fact of increasing the trust that the patients can have in a decision?

Tim Richmond : Well, I mean, OK, yeah, I didn't mention blockchain. So a blockchain is possible, that and this happens all the time with the volume of data that's being generated, it's possible for data to be missed, it is possible for data to be lost. Right. So, especially when you're going, I do not know what health care is like in Belgium, but here in the UK, we have a national health service. But each individual hospital, you may need to go to three or four different hospitals to get the different types of treatment. And the

interconnectivity of that is dreadful. I mean, it's terrible. You know, I I'm very thankful to have an NHS, but at the same time, it's not perfect. And so, yeah, frustration is often that they're working isolated. And so a blockchain in this environment would be ideal because it means that everybody would have access to the same information. Each hospital still has their own way of doing things. So with blockchain, it would be homogeneous. So homogenise, harmonise, the entire system. So that everybody was working in the same way.

Meriyem : What about the discrimination and the unfair biases. Can blockchain help to reduce the biases and the discrimination done by AI?

Tim Richmond : Bias is a really tough one, because every time you have a container of data, it will always be biased because it doesn't contain everything. And so particularly with algorithms. So we can train algorithms to generate other algorithms. So what you get is you get an algorithm that's designed towards a specific goal, but the goal that you set is automatically biased by the very nature of what it is. But if you can create an algorithm which is designed to create other algorithms, then you can eventually get to a point where the original bias is already minimized. But blockchain, when talking about blockchain specifically, one thing is you can create something called a consensus decision making. So this is where you have different algorithms pointing towards the same outcome and then using blockchain to interconnect these algorithms, you can create a central algorithm which then is able to take the data and even it out. But even then, the algorithm is biased in its own way. So this is a major, major problem and something for which there isn't a solution properly yet. But I personally think that it's a bias. An example, actually, we were talking about medical AI and diagnosis. There was a fantastic, amazing girl. She is 16 years old and she created an algorithm. She created an algorithm for identifying pneumonia, this was before the pandemic. And so we tested this thing, and it's amazing that she was able to do it at that age, but there was massive bias towards positive results. And it's because of the data set, there were not enough data. Biased towards one way or another if it's a binary decision. So big data is actually one way to reduce the bias, because you've got access to all the data. So blockchain although it seems like a distributed ledger, being distributed in itself would be one solution to a bias because it creates an equilibrium within the system. At the moment, you introduce any A.I. that is working on a data set, you're introducing bias. And so the only way that I can see that this can resolve is if we interconnect with big data to be able to just have access to as much data as possible. I do not think you ever going to be able to reduce the bias down to zero. If we look at bird wings, for example, there's always one bigger than the other. It's natural. It's part of nature.

Meriyem : Yeah. But then blockchain could help maybe with the accessibility to data to have more data available for training the AI and to reduce for example, discrimination? We could also access more data from all around the world more easily. And the big companies are not the only one that have access to the data?

Tim Richmond : Absolutely right. And all of that is correct. Yeah. Absolutely. The more data you've got access to, the smaller the ratio of bias is. Absolutely a very good point there is that large organizations obviously contain the ability to control this data, meaning that they can make decisions which are good for them, but not necessarily good for everybody. Right. Absolutely. Right. On all points.

Meriyem : And what are the major issues you're thinking about while talking about the integration of blockchain used for AI? What will be complicated and the challenges that we are going to face or you are going to face a singularity to put these two together?

Tim Richmond : So its speed. So at the moment we only have like very few algorithms on there and there isn't a great deal of usage. But as time goes by, we have a spinoff organization called Singularity Studio who is a great organization, which effectively approaches large corporate companies to help them develop AI solutions. But what will happen eventually is this technology will trickle down into the SME market, the small medium enterprises. And so there's going to be a massive adoption. What the problem is, it's a bit like building your country's road infrastructure. If you've got only like small lane roads, people can't get from A to B very quickly. And so the adoption of cars wouldn't be very big. Right. And this is the same problem with blockchain at the moment. AI, and blockchain is fantastic. It marries perfectly together, but it's the speed of the transactions and the volume of transactions being very slow and very small that is holding everything back. And if we can increase the speed of transactions, then obviously, more transactions can happen at once. And so more people would use AI and so it would take off. The other challenge is interconnectivity. So we have all of these blockchains. Right. But they're self-contained within their own environment, so what's needed, there are islands of brilliance. And the problem is that they're then not able to interconnect properly. There are some solutions to this, but every time you create a solution to this, it becomes a centralized system. So it's how do you connect these different types of blockchains while maintaining the decentralization of the overall system? And so this is another obstacle we're working on at the moment. And the third issue is, I mentioned before the ontology of AI algorithms themselves, so we want to be able to have AI able to interconnect with another AI on our own platform. That's what we've designed it for. But we want them to also interconnect with an AI, which has been designed on another platform. Yeah. And so we create what's called an ecosystem of ecosystems. So it's like a massive structure of interconnectivity and cooperation. But what's holding it all back is the scalability of blockchain.

Meriyem : Yeah, OK. And if it's not possible to have interoperability between blockchain, it can prevent to have a massive amount of data available to feed into AI as well, then?

Tim Richmond : Yes, that's right. The primary thing is being able to maintain the decentralization of the system. It's kind of pointless to tie together these ecosystems if there's a central place that's happening. So what I personally believe needs to happen is there needs to be a kind of mechanism that sits in front of the blockchain that is part of the blockchain, and that can lock up tokens or actual coins of one side and release on the other. And then it's not owned by anybody. It's just a protocol. And therefore that would work. But this introduces another resource or another obstacle for the overall system to get over and will slow everything down again. So it's the speed and being able to interconnect. I think quantum cryptography can help with this by increasing the overall speed. But I also think that the structure of blockchain needs to change, OK, and that also means that Bitcoin itself will likely die at some point. Right. So all of these people that are storing, you know, a thousand bitcoins to be trillionaire in the future, eventually it's going to fail.

Meriyem : And what about the development of these two technologies in the developing countries?

Tim Richmond : Actually, this technology has the best impact on developing countries because, you know, singularity that works with Aycock Labs in Ethiopia and we also have an agreement which I forgot the name of the European agency for delivering aid into African countries. Blockchain is an amazing thing for these people because it just means that people who have no ability to access resources can now access it readily. It means that they can monetize their work on the same level as like developed countries. So the technology is liberating for any developing nation that has access to the Internet. And with Ethiopia, they recently shut down the overall Internet. This is how bad it can get. But there's a whole bunch of really amazing things you can do. So like delivering aid via blockchain so you can give people like immutable tokens, which they can exchange for aid and circumnavigating one of the biggest problems of distributing aid into countries that need it, is that it gets eaten up by the warlord or the central body. And it doesn't get to the people that need it. But with blockchain, it's possible to deliver aid to the people that actually need it. And that's another thing as well. Obviously, you've got places where they're literally, you know, there's no electricity, they're struggling to eat, but there's the ability for what's called DAO. So these are decentralized autonomous organizations which are designed to transact, which can create funds to actually deliver into these places. So you can create a decentralized, autonomous organization which collects donations and then is able to distribute those to the right places. So that's amazing as well. But also allowing them to gain access to, you know, a global point of data and allows them to get access to resources that they couldn't do before.

Meriyem : Yeah. So it will be more beneficial for them than for using the developed countries?

Tim Richmond : Yeah, it's beneficial for everybody. So if I give you ten pounds, that's not as beneficial to you as if I gave ten pounds to somebody who is in Africa. So there's a great increase but, ultimately it allows them to put a step on the ladder that they couldn't get on before. There's a lot of really intelligent people. So if I was an AI developer or I was a developer, I would be able to monetize my algorithm and receive money. It's impossible for some of these countries to transact in any kind of currency. So it's possible to monetize that and start to create the businesses and the foundation of every country's growth is each individual person being able to increase their own standing. So if everybody is increasing their own standing, the overall society gets lifted up.

Meriyem : Thank you very much for your time, I've got a lot of information.

Tim Richmond : You're welcome, do not hesitate to contact me if you need more information.

Meriyem : Right, thank you very much. Have a nice day

Tim Richmond : You too Meriyem.

Interview Hubert Ridolphi

Meriyem : Bonjour Monsieur

Hubert Ridolphi : Bonjour Meriyem, comment vas-tu ?

Meriyem : Très bien et vous ?

MHubert Ridolphi : Egalelement, merci

Meriyem : Pour me présenter en quelques ligne, je suis étudiante en 2^e année de master en ingénieur de gestion à Louvain-La-Neuve en Belgique. Je termine mon année avec un mémoire sur la blockchain et l'AI. Ma question concerne le fait de voir comment est-ce que la blockchain peut aider l'AI à devenir plus digne de confiance, qu'elle soit plus sécurisée et adoptée par la population. Je vous expliquerai cela plus en détails par après. Cependant, pour être plus précise, ma question est la suivante : *"Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence?"*.

MHubert Ridolphi : C'est une longue question qui englobe deux domaines qui ne sont pas toujours mariés ensemble. On peut parler des utilisations de la blockchain dans le domaine de la santé, on peut parler de l'AI dans la santé. Pour répondre à cette question, il faut déjà détailler quels sont les utilisations de la blockchain et de l'AI connues dans la santé. Pour l'AI c'est assez facile à trouver, pour la blockchain c'est un peu plus difficile. Il y a justement des consortiums européens pour justement faire de la recherche dans la supply chain de l'utilisation de la blockchain dans le domaine de la santé ou dans les études cliniques pour justement voir si les données ont été frauduleusement transformées, donc on se sert de la blockchain comme outils pour garantir justement cela car si vous changez les données, il va y avoir un checksum qui ne va pas être le même. Nous récemment, on utilise la blockchain pour un échange l'e-prescription entre les médecins, le patient et le pharmacien. Dans tous les exemples que j'ai vu par rapport à la blockchain, c'est vraiment un outil, c'est là pour apporter la confiance par rapport au fait que les données ne sont pas corrompues. Dans le cadre de la modification des données, vous pouvez éventuellement bloquer l'accès à ces données car elles ont été modifiées. Maintenant, j'ai un peu de mal sur comment la blockchain peut apporter de la confiance aux données dans l'utilisation d'une AI, je dirai que la confiance vient du consentement du patient ou pas et qui doit être dynamique. C'est là où je vois la confiance en premier dans la mise en place de ces systèmes. La blockchain, après c'est un outil pour voir que ce sont les bonnes personnes qui accèdent aux données, ça, ça peut être totalement utilisable pour ça. Je me rappelle qu'en 2016 j'ai fait un poc pour une mise en relation de système de base de données médicales avec consentement des patient justement pour transférer les consentements d'une base à une autre. Ça existe mais c'est encore très early stage. Il y a une consonance assez psychologique dans votre question. C'est là où est-ce que la technique peut apporter une sécurité une confiance par rapport à cette composante technologique, oui. Mais l'effet peut être complètement inverse. Parce qu'il y a de la blockchain, on va encore moins croire l'AI. Les deux existent. On l'a vu avec Watson. Il a été très controversé dans ces débuts. Aujourd'hui on en entend presque plus parler, c'est assez un échec pour IBM. Néanmoins, un certain nombre de pilote qui ont été fait chez watson, notamment dans l'analyse des radiologies, des images médicales ont été un succès et reconnus. Après, il y a différente couche qui interviennent dans le trust mais ce sont plus pour les professionnels de la santé. Donc pour le public, est-ce-que la blockchain

peut amener la confiance à l'utilisation de l'AI. Ça fait 2 mots à la mode dans une question, AI et blockchain et je pense que le public n'est pas encore près à ça.

Meriyem : C'est intéressant et justement quand je lis dans la littérature, les articles parlant des deux sont assez rares et ils précisent bien que c'est un domaine très peu exploité et la blockchain est une technologie encore très récente et donc, il peut être difficile de trouver les informations par rapport à cette potentielle révolution on va dire. Ce que j'avais comme idée en tête, c'est de passer à une introduction de votre personne en quelques lignes, ensuite quel est votre lien avec la blockchain et les soins de santé. Ensuite, de passer à des questions un peu plus liées à la blockchain pour voir comment elle fonctionne etc, après, de voir quels sont les problèmes au sein de l'AI et ensuite une troisième partie abordant le fait que la blockchain puisse aider ou non l'AI. Il y a également une dimension que vous avez abordé, c'est celle de dire que le public n'était pas prêt pour la blockchain. Donc ici, j'analyse autant les end users comme les docteurs ou alors les utilisateurs qui vont en bénéficier. Par exemple si l'AI fait un diagnostic, le médecin va devoir croire ou pas au résultat. Celui qui serait directement touché serait le patient. Si l'AI dit voilà vous avez un cancer en stade 4 imaginons, si c'est vrai, le patient doit pouvoir le croire.

Hubert Ridolphi : Pour le moment on en est pas là et je ne pense pas qu'on arrive à ça. Dans tous les cas, les lobbys des praticiens poussent et à raison pour que ce ne soit pas la machine qui l'annonce directement. L'accompagnement au diagnostic est une composante essentielle et je pense que même les régulateurs des medical devices, etc ont prévu que toutes les aides au diagnostic passent en certification parce que il faut un accompagnement professionnel. Ce sont des aides aux diagnostics qui doivent être medical software.

Je vais me présenter rapidement, je suis pharmacien industriel de formation, j'ai travaillé pour l'industrie pharmaceutique, la biotechnologie, pendant un certain nombre d'années, j'ai eu mon diplôme en 1992. J'ai fait également une dizaine d'années de consulting pour le produit de biotechnologie from bench to market, donc toute la phase clinique, pré clinique, toutes les phases cliniques jusqu'à la phase 3 puis les post cliniques en phase 4 puis tout l'aspect commercial avec l'accès au marché, remboursement, etc. J'ai aussi travaillé pour des produits digitaux pharmaceutiques. Ce qui m'a amené en 2015 à travailler pour une société qui s'appelle prive qui vend un middleware, un logiciel qui permet le traitement des données personnelles en conformité avec les réglementations et qui est très adaptée à la gestion des données de santé. C'est là où avec nos clients qui étaient des sociétés d'études cliniques, on a été amené à développer des pilotes blockchain qui permettait un audit trail de l'essai clinique, des données de l'essai clinique et permettait de prouver qu'elle n'avait pas été modifiée par un opérateur, par un médecin ou par un laboratoire et donc permettrait de montrer que le produit testé avait eu une influence positive. Après j'ai retravaillé pour une société Allemande qui est un laboratoire central d'analyse et une société de préparation de médicament d'études cliniques et j'ai rejoint le cas en début d'année où je suis responsable pour l'e-santé sur toute la Suisse pour nos projets qui touchent à la fois les hôpitaux, les cliniques, tout ce qui est life-science qui touche à toutes les données patients qui soit dans des maisons de repos, etc. Il y a un certain nombre de solutions que l'on propose qui utilisent la blockchain. C'est disponible sur notre site internet et vous pouvez trouver notre système de prescription électronique garanti par la blockchain. Vous pouvez y voir l'explication où la prescription est faite par le

médecin, de manière électronique mais qui reste sous le contrôle de la blockchain. Le patient garde ses données de prescription et qui peut les modifier éventuellement mais n'a pas le droit car le pharmacien va vérifier en utilisant la blockchain justement la validité de la prescription, si elle a déjà été délivrée, si le dosage a bien été indiqué par le médecin, etc etc. C'est cela qui est en train d'intéresser un certain nombre de client chez nous.

Meriyem : Pour commencer, comment définiriez-vous la blockchain ?

Hubert Ridolphi : Pour moi la blockchain c'est un outil. Ce n'est pas une fin en soi. C'est un outil qui permet de techniquement montrer la confiance des utilisateurs et des contributeurs à un système. Ça permet également d'amener la transparence ainsi que la privacy et l'auditabilité. Je vous conseillerai d'essayer d'interviewer Travin Keith qui est un des pères de l'hyperledger, qui vous donnera un petit peu plus sur le côté blockchain. Il voit très bien les obstacles et les limites de la blockchain, surtout la compréhension de celle-ci. Elle commence à sortir de son domaine financier, elle commence ! Il y a très peu d'utilisation dans la santé. Mais néanmoins, c'est quand même intéressant de voir les initiatives autour de ça.

Meriyem : Selon vous, quelles sont selon vous les challenges que rencontre la blockchain en termes d'adoption et d'implémentation dans le secteur de la santé ?

Hubert Ridolphi : L'implémentation n'est pas un challenge. C'est vraiment facile l'implémentation de la blockchain. Ça peut sembler difficile pour une personne « non technique » mais la blockchain est vraiment un outils et je vois des gens développer la solution blockchain pendant une pause-café, la codant et s'assurant qu'elle fonctionne. Concernant l'aspect technique, ce n'est pas compliqué. Mais l'application est compliquée. Tu dois trouver la bonne application, ou la blockchain va amener quelque chose. Parce que tu peux faire énormément de choses en lien avec la sécurité parmi les outils qui sont disponibles sur le marché, outils pour encrypter, hedge computing. Donc la décision d'utiliser la blockchain comme étant un outil permettant de prouver la confiance doit être mesurer.

Meriyem : D'accord, merci et quels sont les avantages de la blockchain ?

Hubert Ridolphi : très facile à implémenter. Puis également, tu ne dois pas partager l'information. La blockchain ne sert pas à partager les données mais à prouver que les données sont partagées. C'est d'un autre niveau pour moi. Tu ne dois pas utiliser la blockchain pour stocker des données, tu utilises la blockchain pour partager des données. La blockchain ne sait rien par rapport à vos données. Tu garantis le partage de données sans avoir les données au sein de la blockchain.

Meriyem : Et donc les données se trouvent ou à ce moment-là si la blockchain ne sert pas entre guillemet de database ?

Hubert Ridolphi : Ils peuvent être directement dans les mains du patient, ça c'est un avantage car aujourd'hui on est beaucoup plus patient-centric. Je vous renvoie aux réglementations autour des données sensibles que sont les données de santé. C'est données peuvent être dans les mains du patient ou dans un serveur qui a tous les niveaux de garanties requis par les communautés européennes ou tous les standards du pays dans

lesquels il est stocké. Voir même qu'il peut être crypté de manière sécurisée avec tous les systèmes d'encryption qu'on a aujourd'hui.

Meriyem : Et maintenant, avec le fait que vous disiez qu'un patient possède ses propres data, on dit dans la littérature que la blockchain permet justement de protéger l'identité du patient, ou que la vie privée est maintenue, si maintenant il veut justement partager ses datas, comment la blockchain peut aider ? Comment la protection de son identité peut être maintenue ?

Hubert Ridolphi : Encore une fois, dans la blockchain, il n'y a pas ces données. C'est le patient qui va consentir à donner un certain subset de ses données, qui ne contiennent pas son identité ou qui sont pseudonymisées ou complètement anonymisées en utilisant la blockchain pour justement vérifier que ces données sont partagées avec la bonne institution ou la bonne personne. Et éventuellement, une fois que la preuve que ces données sont partagées et utilisées, d'avoir un retour. La boîte Zentiva, a lancé une application où vous pouvez justement stocker sur des serveurs sécurisés vos données de santé et les partager avec des acteurs pour la recherche, et donc en utilisant la blockchain, pour la recherche et vous recevez en retour des goodies. Ça peut être une réduction pour aller au théâtre, un genre de crypto monnaie que vous pouvez utiliser très facilement. La privacy c'est le pouvoir de partager avec qui on veut ses données et d'arrêter ce partage en étant sûr que ces données ne sont plus en possession du partenaire avec qui vous les aviez précédemment partagées. Et la blockchain permet ça aussi, ou alors une gestion des consentements plus drastique, plus sécurisé.

Meriyem : Et si maintenant, on doit utiliser une blockchain au sein du domaine de la santé, je lisais que parfois, il y en avait plus pour l'utilisation publique de la blockchain au sein du secteur de la santé. Étant donné que les avis sont controversés, et étant donné que les data sont assez sensibles, laquelle est idéale selon vous.

Hubert Ridolphi : Je dirai sans équivoque, la public blockchain car à partir du moment où tout le monde peut vérifier, seule la public blockchain va être encore plus trustée. Bien sûr qu'on peut avoir confiance en une blockchain privée. Dans le cas du B2B, c'est très utilisé. On a une filiale qui fait un produit qui permet dans l'organisationnel, donc organisateur de spectacle, de festival, les JO, ou autre d'émettre les billets pour leur événement qui sont sécurisés par la blockchain et peuvent donc être tracés. Savoir par qui ils sont partagés. Donc vous ne pouvez plus avoir quelqu'un qui achète ses billets à 10\$ et les revends à 100 parce qu'il n'y a plus de billet sur le marché. Vous pouvez bloquer ce style de trafic grâce à la blockchain. Et ça c'est une blockchain privée car c'est une utilisation privée par rapport à un système qui n'implique pas les données personnelles des gens et implique un produit papier classique. Mais la blockchain publique apporte véritablement le trust. Maintenant, la problématique derrière le développement d'une blockchain publique c'est le coût, ça coûte très cher. Ça peut coûter des milliers. Si ce sont les utilisateurs qui partagent leurs données médicales qui est important, à ce moment-là, vous avez tout intérêt à avoir une blockchain publique. Si c'est pour une application pour une maladie dans un système, à ce moment-là les simples accords directs garantissant les consentements dynamiques etc n'a pas besoin de faire appel à la blockchain. Le coût dépend donc de votre modèle et de votre business model.

Meriyem : D'accord, merci. J'ai une dernière question par rapport à la blockchain. Quand je lis au sujet de la blockchain et que je lis concernant le consensus, je tombe souvent sur le proof-of-work, ce qui nous amène à confirmer qu'au niveau environnemental cela utilise énormément d'énergie du au computational power qui sont importants. Mais j'ai l'impression qu'on ne parle pas beaucoup des autres solutions mis à part d'autre système comme le Proof-of-stake ou autre mais comment obtenir un consensus par exemple pour une application au sein du domaine de la santé ?

Hubert Ridolphi : L'environnement de la santé, il est hyper régulé, que ce soit pour la fabrication et les différentes normes autour de ça. Même dans le medical software, c'est régulé. Il y a un certain nombre de prérogatives, ISO1385 qui sont à suivre, plus des frameworks sur le développement des softwares. Vous êtes déjà dans un environnement régulé qui va lui-même rentrer dans un environnement aussi régulé, à l'hôpital, lors de la prescription d'un médicament, lors du test d'un médicament qui va se faire dans un centre clinique qui se situera aussi à l'hôpital. Le fait de se poser la même question que pour une cryptocurrency qui doit se démarquer par rapport aux vrais monnaies papier émises par des banques centrales, qui est garantie par des États et des signatures. Je vous rappelle les billets de banque anglais a marqué que la reine vous garantit le paiement fixe si vous lui présenter ce billet. La confiance est là par la signature. Si vous avez la signature de Christine Lagarde sur le billet de 5 euros, c'est parce que il y a le trust de la Banque centrale européenne. La confiance de la Cryptocurrency, elle vient de nulle part. Il a que la technologie pour accroître son trust, donc on est obligé de faire ce que vous décrivez avant le proof-of-work, etc. Dans la santé, on ne peut pas se poser la même question. C'est complètement irrelevant, sauf si je vais utiliser un système qui est aux États-Unis, mais je vais me poser plein de questions en tant que patients auxquels la blockchain ne va pas forcément pouvoir me répondre. Parce qu'encore une fois, le cadre de la régulation des données est différent. C'est l'environnement qui crée la confiance ou la non confiance, bien entendu. Je ne pense pas, au jour d'aujourd'hui, que la blockchain puisse être une solution à cette question de confiance ou pourrait aider à apporter plus de confiance par rapport à un environnement qui est untrust. Et vous pouvez visiter le site Zentiva. Je vous l'envoie pour le noter. C'est une application qui sait monétiser les données patientes contre échange de goodies, comme je vous ai expliquer.

Meriyem : J'ai une autre question, vous dites que c'est l'environnement qui crée la confiance. Avez-vous un exemple de comment cet environnement peut donner de la confiance aux gens ? Vous pensez alors que l'on pourrait faire un système décentralisé sans avoir un consensus pur et dur.

Hubert Ridolphi : Je pense que la blockchain peut apporter le lien entre ces différents intervenants qui sont déjà très proches et se faire confiance les uns les autres, mais qui pourrait justement apporter ce lien de sécurité par rapport au partage ou à l'utilisation des données. C'est le lien technique, c'est à dire que c'est en fait le reflet de la confiance dans la vie réelle qui va être mis sous forme technologique. Mais, ça reste qu'un outil. Encore une fois, il n'y a rien de conceptuel. C'est un outil qui permet justement la mise en relation de personnes qui sont déjà trusté. Après, il faut bien entendu, il faut des critères d'enrôlements. On va toucher un autre système, c'est à dire l'identification des personnes. Là, il y a des solutions sécurisées qui vont permettre l'identification des personnes et la preuve que c'est bien cette personne qui utilise un tel système. Et puis après sera mis en

relation grâce à la blockchain avec une autre personne qui utilise le même système et dont l'identité est aussi vérifiée. C'est un outil, il n'y a rien de mystique.

Meriyem : D'accord. Quels sont selon vous les challenges dont fait face l'IA ?

Hubert Ridolphi : Entraîner l'algorithme est un problème, il y a un manque de data, et spécialement dans les maladies rares.

Meriyem : Il y a un schéma que je voulais vous montrer, que j'avais trouvé et que j'ai utilisé pour ma littérature review. Il disait que la blockchain pouvait être utilisée pour l'IA et l'AI pour la blockchain. Au sein de mon travail, je me suis concentré sur un des deux, donc à savoir, comme je vous ai dit, la blockchain pour AI. Et dans la blockchain pour l'AI, il y a un schéma qui disait et plusieurs littératures qui disaient que, du coup, ça pouvait aider sur 4 à aspects, dont : explainable AI, data sharing and marketplace for AI et alors coordination untrusting devices. Et donc ça, c'est les 3 points sur lesquels moi, j'ai essayé vraiment de me concentrer.

Hubert Ridolphi : Oui, mais encore une fois, on touche à 2 systèmes informatiques différents. Quand vous avez un network de device ou de medical device, puisqu'on reste dans notre domaine, dans le domaine que je privilégie déjà au jour d'aujourd'hui, la régulation va prévoir qu'il y a un unique identifiant par device, ce qui permet de les identifier formellement. On en revient aux problématiques de confiance dont on parlait auparavant donc le partage entre différentes personnes, device qui sont truster et identifier. Chaque device peut avoir un UID, un unique identify number device, qui va justement pouvoir produire des données à partir des données patients, par exemple. Et ces données, elles vont être stockées dans un système qui va utiliser l'intelligence artificielle pour l'interprétation. On pourrait éventuellement faire de la prédiction par rapport à ça en fonction du training de l'intelligence artificielle. Le machine learning, c'est bien, mais ça a ses limites dans la santé parce que l'on n'a pas suffisamment de données. C'est la difficulté de l'AI en médical, c'est d'avoir quelque chose qui puisse montrer qu'on a suffisamment d'entraînement de l'algorithme sur un certain nombre d'image, pour dire, là, cette tumeur elle va évoluer comme si, comme ça, votre cancer d'un point de vue TMN, c'est ça, c'est un T3, etc. C'est l'AI qui va faire ça. Mais pour ça, il faut l'entraîner. Ce qui manque aujourd'hui, c'est des bases de données. Pour le moment, ce n'est pas probant. Sur certains cancers, ça commence. Il y a eu l'exemple de Watson, mais malgré ça, ce n'est pas encore probant pour que en production on puisse sortir des systèmes qui, justement, vont utiliser l'AI pour faire ce type de diagnostic. Ce qui est probant de l'utilisation de l'intelligence artificielle, c'est d'avoir des choses déjà sur des éléments de traitement, tel ou telle médication dans tel ou tel cas. Là, on a beaucoup de données, on en a plus que sur l'imagerie de disponible donc on peut préconiser des schémas de traitement en fonction de certaines maladies. Mais encore une fois, la blockchain sera là pour dire que les données qui sont fournies par les systèmes, que ce soit humain ou machine, proviennent bien du bon individu ou de la bonne machine. Et après, ces données seront analysées par une intelligence artificielle.

J'ai un peu de mal avec les comment dire, le mélange un peu des deux, c'est très comment dit disruptifs. Mais il y a des choses qui sont, dans la recherche biomédicale, qui sont utilisées je pense avec une des collaborations entre des systèmes trustés grâce à la blockchain et après analyser avec intelligence artificielle.

Meriyem : Par rapport aux secure data sharing, de ce que j'ai vu de la littérature, c'est plus comme vous l'entendez. C'est vraiment le fait qu'on peut s'assurer que les datas sont safe, secure, viennent de la bonne source, etc. Qui n'ont pas été tampered et après, ils sont justement utilisés dans l'AI. Et donc, ce qui fait que ça peut répondre déjà à un des problèmes que l'IA rencontre, je ne sais pas si vous êtes d'accord ? L'IA rencontre certains problèmes comme des biais parce que justement, les data ne sont pas safe, etc. Je pense qu'il y a une entente dans ce sens-là au sein de la littérature. Je ne sais pas si vous êtes d'accord, mais c'est un peu l'exemple que vous venez de donner.

Hubert Ridolphi : Je suis 100% d'accord. Je voulais l'illustrer au départ avec l'utilisation de la blockchain pour faire l'audit des données d'études cliniques pour voir que ça n'a pas été tampered, ça oui. Oui, la blockchain est là pour vérifier que ces données n'ont pas été modifiées.

Meriyem : Voilà, c'est exactement vers ça que je voulais me diriger et répondre aux problèmes de l'intelligence artificielle. J'en ai énuméré plusieurs au sein de mon travail comme la discrimination, des biais, de la qualité des data, availability and provenance, transparence des data et également, la transparence par exemple des décisions qui ont été prises par l'AI. C'est un point qui s'attaque à la transparence et explainability parce que, comme je lisais dans la théorie, c'est un peu difficile, même pour un médecin, d'expliquer une décision qui a été prise par une machine parce qu'elle prend beaucoup de facteurs en considération. Et après, c'est la machine, qui est là pour ça, ce sont des algorithmes qui trouvent une solution, on va dire entre guillemets et donc c'est comme ça qui pourrait donner un traitement, même si c'est dans le futur comme vous avez dit. Et alors, par rapport à cela, c'est se dire, voilà la décision a été prise, mais quelles sont les étapes qui ont été faites pour arriver à cette décision ou quels sont les datas qui ont été utilisées ? On peut s'assurer qu'ils n'ont pas été falsifiés et que nous pouvons les tracer.

Hubert Ridolphi : Oui, tout ça c'est grâce à la blockchain. Mais vous avez cité plein de caractéristiques dont l'intelligence artificielle a besoin qui n'ont aucun rapport avec la blockchain, qui ne sont pas traitées dans la blockchain. Comme lesquels par exemple ? Data quality, à part le fait que c'est untempered, qui est un facteur primordial, mais on va dire que la data quality, quand vous faites un data lake par rapport à des données, que vous centraliser à partir de différentes sources de données, que ce soit des devices, des données qui sont récupérées publiques ou que vous acquérez via un data broker, ces données, il va falloir les nettoyer pour avoir de la qualité de données. Et donc, vous développez un processus de data cleaning pour avoir finalement des données exploitables sous le même format. C'est pour ça qu'il y a bien un format OMOP utilisé dans les études cliniques, qui est aussi souvent utilisé, qui vous permet d'avoir les données structurées de la même manière. Donc, les algorithmes vont pouvoir tourner beaucoup plus vite avec ces données structurées. C'est ça la qualité de la donnée. C'est avoir une donnée structurée, sans déchet. Mais là où la blockchain peut interférer avec l'intelligence artificielle, c'est que l'intelligence artificielle va avoir besoin de set de données longitudinales, c'est à dire dans le temps par rapport aux données de santé. Et ça, c'est important quand vous voulez faire de l'integrated care, par exemple, vous voulez soigner quelqu'un, mais voulez savoir qu'à 20 ans il a fait une appendicite, que son grand père a fait un cancer de la prostate, que ceci, que cela, là vous allez pouvoir faire de l'integrated care. Donc il va vous falloir de la donnée de qualité par rapport à l'historique d'un patient. Et dans le temps, je parlais du grand-père exprès pour l'illustrer. Et donc là, le patient va devoir partager ses données. Et la

blockchain peut apporter la confiance pour qu'il partage ces données et pour que l'intelligence artificielle derrière puisse l'exploiter ? Mais c'est là où je vois le lien. Après, encore une fois, c'est deux mondes, il faut voir la chaîne de valeur de la donnée. Si j'étais vous, je mettrais en quelque sorte une chaîne de valeur de donnée pour être exploitée par une intelligence artificielle ou par des algorithmes développés par des data scientists. Et c'est ça qui me permettrait d'illustrer l'intervention de la blockchain pour le partage de données et après l'intelligence artificielle pour l'exploitation de cette donnée, sachant que les données anonymisées ont beaucoup moins de valeur que les non anonymisées. Si vous avez besoin de revenir aux patients, si vous traitez des données anonymes ou si vous agissez à partir de données anonymisées, vous ne pouvez pas revenir au patient. Et c'est pour ça que la gestion du consentement est très importante. La gestion dynamique, qui peut être retirée à tout moment, est importante dans le temps pour apporter un résultat de qualité par rapport à une intelligence artificielle. Pour l'entraînement de l'intelligence artificielle, ça peut se faire à partir de données anonymisée bien entendu, c'est deux phases de l'intelligence artificielle. Il faut voir la chaîne de valeur de données dans le healthcare.

Meriyem : D'accord, merci beaucoup. Après, il y a d'autres problèmes auxquels l'AI doit faire face comme gouvernance & legal aspect, ça je ne suis pas sûr que ça puisse apporter quelques choses, mais qu'en pensez-vous ?

Hubert Ridolphi : Ça se gère au niveau de l'entreprise.

Meriyem : D'accord donc selon vous, la blockchain ne peut pas apporter de solution à cela ? Il y a également le privacy & cybersecurity, par exemple privacy of data's owner and the fact of gathering them.

Hubert Ridolphi : Même au niveau de la gouvernance. On peut très bien édicter dans une gouvernance que tous types de données X,Y doit être être anonymisées et accessible via un système de blockchain et d'identification trustés ou via un système d'identification trusté par la blockchain. C'est là où on peut faire le lien. Chaque fois, à chaque fois que vous avez relevé, la gouvernance. Pour la privacy, comme je l'ai expliqué, c'est le fait de pouvoir partager avec qui on veut ses données. Donc là, je vous renvoie peut-être à des sociétés comme prive dans laquelle j'ai travaillé. La privacy, c'est vraiment le pouvoir de partager et de non partager et s'assurer, pourquoi pas via la blockchain que les données n'ont pas été copiées. Parce que ça laisse une trace dans une blockchain. Après, il y a d'autre systèmes qui peuvent être utilisés.

Meriyem : Egalement, par rapport à la discrimination, comme par exemple, dans la revue de littérature, j'ai pu lire que l'AI, pouvait discriminer certain genre dû au fait que le système est souvent entraîné sur des données très occidentales parce qu'on n'a pas les sources dans les pays en voie de développement, ou pour les personnes à mobilité réduite. Je pense que c'est aussi parce qu'il n'y a pas beaucoup de données sur ces personnes.

Hubert Ridolphi : Oui, c'était un peu le problème général de l'AI c'est l'entraînement de l'algorithme qui n'est pas approprié. On le voit dans les robots qui vous répondent, c'est du machine learning derrière, et les réponses ne sont pas toujours appropriées parce qu'elles ne sont pas culturellement teintées. Donc oui, vous avez tout à fait raison, mais ça n'a rien à voir avec la blockchain.

Meriyem : D'accord, et alors par rapport à transparency et explainability, on en a déjà parler mais pensez-vous que la blockchain peut aider, comme on a dit, au niveau de la transparence des données et des résultats obtenus également

Hubert Ridolphi : Sur la transparence, sur la sécurité ou sur le partage sécurisé des données, la blockchain peut apporter. Maintenant, sur la qualité des données, la donnée elle-même, non. Mais la source des données, oui. La blockchain peut apporter du trust, tant qu'elle soit publique et auditable par tout le monde. Je ne connais pas grand monde qui audit les blockchain cependant.

Meriyem : Pourrait-on du coup utiliser la blockchain également pour le fait que si une décision est prise par l'AI, mais il y a eu un problème dans le résultat. Il était erroné et a porté atteinte à une personne. C'est la responsabilité de qui ? Est-ce qu'on peut expliquer comment la décision a été prise, les étapes qui ont été entreprises par la machine grâce à la blockchain ou pas ?

Hubert Ridolphi : C'est super copilote tracté, c'est à dire tiré par les cheveux. Je ne pense pas qu'on intervienne au même niveau. Si vous, vous développez un système qui utilise l'intelligence artificielle pour l'aide au diagnostic, vous allez devoir répondre à des réglementations. Ces réglementations, en fonction si vous mettez en danger, plus ou moins le patient si c'est life threatening, vous allez être en 2B voire 3A. Et là, c'est une AI qui est utilisé dans les médecines d'urgence comme aide à la décision. Et là, vous avez un législateur qui a prévu un certain nombre de garde fous pour mitiger ce style de risque et donc l'AI ne va pas délivrer si on est en dehors de ce range de capacité de décision, l'AI va s'adresser directement aux médecins et non plus aux patients et va dire que vous devez prendre la décision par rapport à ça, je ne peux pas vous aider. C'est le législateur qui prévient le cas que vous disiez. Malgré toutes ces précautions, ça peut arriver à ce moment-là, c'est le fabricant du système qui va être responsable de la décision de l'intelligence artificielle d'un point de vue juridique. Ce n'est pas l'exploitant du système qui aura fait le mauvais geste. C'est le fabricant. Du coup, le fabricant met toujours un warning par rapport au conseil qui donne. Il dit cette décision doit être prise en fonction de votre âme et conscience. C'est purement de l'aide à la décision

Meriyem : J'aimerais savoir si l'intégration technologique est bien acceptée selon vous. J'ai quelques questions, mais qui vont assez rapidement. Est-ce que vous pensez que l'intégration de ces deux systèmes, donc utiliser la blockchain pour l'AI peut améliorer l'intelligence artificielle et la performance des médecins ou autre utilisateurs ?

Hubert Ridolphi : Je pense qu'à moyen long terme, on verra des use case qui utiliseront les deux. Ça c'est sûr. Maintenant, est ce que l'un peut aider l'autre, comme on l'a expliqué avant, ce sont deux domaines séparés. Il y a la confiance d'un côté, la confiance dans les intervenants qui utilisent le système et le côté de l'intelligence artificielle, c'est à dire la confiance dans le fait qu'elle est suffisamment entraînée pour donner la meilleure réponse. La blockchain ne va pas aider l'AI à apporter la meilleure réponse. Et l'AI ne va pas aider la blockchain à apporter la confiance donc je suis partiellement d'accord, d'un point de vue technique ce n'est pas incompatible, c'est une complémentarité. Ça, c'est clair. Mais je pense que oui, il va y avoir des choses qui vont utiliser la blockchain mais on ne le saura même pas. Ce sera un outil ou on vous dira que c'est garanti par un système de blockchain qui permet justement de prévenir lors d'audit que ça a été ou pas modifié

et donc qu'il va éventuellement avertir l'intelligence artificielle comme quoi elle ne doit pas prendre cette décision parce que c'est les questions qui deviennent ou des données qui viennent d'une personne non trustée par le système. Ça, c'est un cas d'utilisation ou on verra les deux collaborer. Sinon, on est dans le futur.

Meriyem : C'est intéressant de savoir que c'est dans très longtemps.

Hubert Ridolphi : J'avais googlé le sujet à l'époque où on a commencé à en parler. J'ai vu qu'il y avait des systèmes qui montraient la complémentarité, mais je n'ai jamais vu encore de choses tangibles, des use case qui puissent être vraiment dans les soins de santé, ça sera dans le futur.

Meriyem : Et vous pensez que ça va être facile d'implémenter la blockchain pour l'AI à certains niveaux va-t-il y avoir des challenges ?

Hubert Ridolphi : Moi, je pense que le challenge il est global par rapport à l'acceptation de l'intelligence artificielle. On a fait une mission pour un gros client du secteur public et certains de ses process allaient être aidés par l'intelligence artificielle. Il y avait dans l'analyse des risques, les deux premières lignes, c'était l'acceptation de l'intelligence artificielle par les différents intervenants, avec les questions qu'il fallait mitiger en avance, est ce que ça va me remplacer dans mon poste, par exemple. Et ça, c'est des questions naturelles que l'individu va se poser. Donc forcément, tout ça, il va falloir que ça soit plus claire que ça l'est aujourd'hui. Ou c'est encore réservé soit à des films de science-fiction, soit la réalité. On voit l'échec de Watson, le semi-échec de Watson plutôt. Je ne vais pas me faire des copains chez IBM. Je pense qu'il y a beaucoup de littérature autour de Watson, très positive parce que c'est très trié sur le web mais vous trouverez aussi des choses où ça montre les limites de l'intelligence artificielle. Donc, je pense que oui, mais ça va mettre du temps.

Meriyem : D'accord, ça répond à la dernière question. Et vous pensez qu'avant qu'on puisse utiliser cela pour l'intelligence artificielle, il faut augmenter d'abord l'éducation par rapport à la blockchain pour que les gens savent plus en quoi cela consiste et ce que ça peut apporter ?

Hubert Ridolphi : Oui, C'est comme dans tout domaine nouveau, il faut déminer le terrain, peut être comment expliquer l'utilisation de la blockchain autrement que pour faire des cryptocurrencies. Ça commence un petit peu les articles là-dessus mais c'est difficilement vulgarisable, donc accessible. Mais ça commence et il est évident que l'éducation, ça sera la clé de l'adoption de la blockchain par des utilisateurs si vous voulez monter un business baser sur la blockchain qui ne soit pas une cryptocurrency.

Meriyem : et qu'elle est votre impression par rapport à ça ?

Mr Ridolphi : C'est encore tôt

Meriyem : Et j'ai une dernière question par rapport au développement de ces technologies dans les pays en voies de développement, ce sera plus difficile dans les pays développés ou en voies de développement ?

Ridolphi : Dans les pays développés, les pays émergents sont moins réticents à adopter de nouvelles technologies en général.

Meriyem : Merci beaucoup, vous avez répondu déjà à pas mal de question et je ne vais pas vous tenir plus longtemps. Un tout grand merci.

Hubert Ridolphi : Avec plaisir. Bonne journée.

Meriyem : Bonne journée.

Interview Joan Van Loon

Meriyem : Hi Mr Van Loon, how are you?

Joan Van Loon : Good, thank you and you?

Meriyem : Fine, thank you. Thank you for joining the call. I will present myself quickly. My name is Meriyem and I am a second year master student in Business Engineering, here in Belgium. And I am finishing my master with a thesis about how blockchain can impact AI. How the trustworthy technology of blockchain can positively impact AI: exploratory research for technological and ethical aspect in healthcare. Could you introduce yourself, your relation with blockchain and AI as well as with healthcare?

Joan Van Loon : Yeah, it's will be more AI than blockchain in my case. So I'm in I.B.M. managing director know IBM, Belgium and Luxembourg and a member of the board and in that context responsible for the public sector, which includes government Healthcare, life sciences and education, also the telco industry and the energy and utilities industries. I'm also a spokesperson for IBM Belgium and specifically for everything which has to do with technology AI in health care. And my background is mainly, so through my career, my background is mainly in health care and life sciences. I've been a male nurse and have a master's in Applied Economics and I have a post graduate in health economics. So that's why the interest in health care and life sciences.

Meriyem : OK, thank you. But then I think that the first one is not especially related then for you because it's really about blockchain?

Joan Van Loon : Yeah, I do presentations, of course, for universities and for pharmaceutical companies, and we focus on technology for health care and that includes AI which is the largest part of it. It also includes blockchain. So I know about blockchain. I know how it works or could work within health care. But I'm not a blockchain specialist. Because blockchain and AI are two completely different technologies and blockchain is mainly about all these different sets of information, all these blocks of information that are related with each other through processes. So companies working together and having to share information from one to the other, making sure that this spot you mentioned is in a secure way so that nobody could change the data or tamper with the data and that it's open to everyone in the network. And that is why it is very relevant in health care from that perspective, because in health care, you have the labs, you have the hospitals, you have the patient, you have the pharmaceutical industry, you have the regulators, you have the payers, so the insurance companies, you have you have the pharmacies, you have the distributors. So there are a lot of players who all have different sets of information. So the simplest one is if you take a patient's record, so your medical health record. So this needs to be shared between a hospital and your GP, between your GP and a specialist, maybe between the pharmacist. So sharing this data in a secure way, making sure that all these parties have the same view on all the data and that nobody could change the data as such but every change is registered. That is the advantage of blockchain in health care. And traditionally, when you talk about a database. So blockchain is not one database. It's really a change of information blocks. And of course, everyone in this chain has their database with their own data. But part of it is that shared with the rest, and that is what makes the

change. So traditionally, all these parties had their own data source, so their own databases and they were not connected with the others. So it was just their step in the process without looking at the inflow and without looking at the outflow. And that is where blockchain comes in. So it's now distributed to all these data stores. They are shared with each other. The data is shared. It is shared in real time. So whenever a pharmacist makes a change because he delivers the product to a patient automatically, this is stored in the patient's records whereby the doctor, his GP, can see that the product has been delivered. So that's the way that blockchain can be used within healthcare.

Meriyem : OK, thank you. But maybe I think we can go through it.

Joan Van Loon : Yes we can go through it. That doesn't require a database. Yes. Because the data needs to be stored somewhere. Will there be multiple writers. Yes, of course, because that's the concept. Is there a lack of trust? Not necessarily. But of course a blockchain helps to build trust. So you also think that one, is there a lack of a trusted intermediary? Yes, that's clearly the case in health care. Can a consistent set of rules help achieve the outcome? Yes, of course. Otherwise, you wouldn't go for blockchain. Will the governing rules be consistent over time? Yes, because this concept of blockchain. Is transparency an important feature. Not necessarily because some of the data will need to be visible only for some of the parties, so it's not about sharing a patient's record. Again, it's not the idea that everybody sees everything from the patient's record to the pharmacist only sees the part that's relevant for him. So there is transparency, but on the level of authority of access, OK, immutable, auditable records, because that is basically what blockchain is about. So it cannot be changed. It's auditable. So you can always control afterwards which data have been entered. Which information has been entered, transaction dependent or interrelated. Yes, because it's a chain. So when a pharmacist delivers the product to the hospital and the doctor will see that the product has been delivered. So it is a chain. And can a distributed infrastructure reduce the risk of censorship or attack? It reduces the risk that that's why blockchain because it's auditable and everything is visible and everything is collected. You can build in the security of data tampering. So I would say yes on everything transparency depends on. So it's limited to the access you have and to the authority you have to see some of the things.

Meriyem : And if I come back to the immutability in the literature review, I've read, like, for example, if a patient wants his data to be forgotten, normally he should have the right to ask for it, like in the GDPR or something like this. So maybe it can be an ethical issue, uh, in the future. So what do you think about this?

Joan Van Loon : Well, GDPR indeed. You can, as an individual, ask for you to be forgotten, but not always so as a patient, the data they have on you is basically because it's relevant from a business perspective. So you cannot ask from a GDPR perspective, please remove the fact that I have cancer. I mean, you have cancer or cancer or whatever disease you have that disease. So that's a fact. So you cannot say I didn't have that disease. So that's the difference. So, for instance, if you register yourself at Google or Nike, you can say, OK, I do not want you to have any data about me that needs to be removed. That's GDPR. But within health care, there are also specific rules which are even stronger than the GDPR rules for health care because about personal data, personal sensitive data. But these data cannot be erased. You cannot ask to erase, for instance, your age or you cannot ask in the context of a medical file I mean, because it is relevant

information, the only thing is that it cannot be shared as such with everyone. So that is that is basically the auditability of it and the fact that it needs to be transparent. So a doctor can see a lot of information. You can ask if you change from one doctor to another, you can ask to shift your medical records from one doctor to the other so that the first one doesn't see your data anymore because he is no longer your doctor. That's possible. But the medical record as such will still exist with all the data. It only will be accessed by another person.

Meriyem : OK. And if now, we talk about the issues, so it's still related to blockchain, but about governance, how is governance like created and maintained?

Joan Van Loon : Yeah, well, there's no difference in health care or other industries, so the concept of blockchain is the same everywhere. So and the governance is maintained through the fact that it is an open network. So everybody who is part of the network with permission. So you have to be permitted to be part of the network to see some of the transactions, to see some of the data. And then it's basically self-regulating. So it is kind of a virtual chain of of people working together around the data. And every part of the chain can see part of the data can do part of the transaction. That is that is how it's regulated. So it's not governed in the fact that there is a governance board above it. So it's a virtual concept and it's governed basically by the people part of the blockchain. They make sure that. So the auditability is also a part of the concept of the blockchain.

Meriyem : OK, and how is the identity of the patient established?

Joan Van Loon : Of the patient or whoever is in blockchain, basically, that's through the permit and the access. So you have this authority levels. You have what we call identity and access management. That is the technology that makes sure that, you know, that this is really the person and that's different ways to do it. In Belgium, for instance, we already have for a long time our electronic passport. So through that passport, you can identify doctors have their own codes to really identify themselves as a doctor. So there are plenty of ways to identify the identity of the person, but then also access management, which means that you can on each level, so on the level of the database, but also on the level of the specific information, you can define who has access to that information, who can see that information, who can who can change that to that information. So on all level, you can manage the access. So that's pure technology. That's not specific. On blockchain, you will see that in a singular database that it also works on that way.

Meriyem : And do you think that with the fact that blockchain is anonymous? Maybe with hacking and stuff like this, there will be able to find the identity of the one who did the transaction or I mean, who exchanged information or it's kind of safe for you, you think?

Joan Van Loon : Well, basically in a blog, nobody is anonymous. I mean, if a doctor does something in the blockchain. The ones who are in relation with a doctor, know that that is their doctor. So the idea of block change is not to be anonymous. Of course the patient needs to be anonymous, but not everybody in the chain can be anonymous because then you basically break the chain, if a doctor prescribes something, the pharmacist wants to be sure that it is that doctor. So, again, depending on what you have in this chart, you have all these transactions and in a transaction between two parties, the two parties are known. So you do not do a transaction with an unknown party. That doesn't mean that all

the other parties in the blockchain will know that transaction happened. They will know that who those two people are. Only if they have the permission to know that they will. Mm hmm. So but every transaction between one person and another, two persons are unknown.

Meriyem : OK, and how are inputs verified and transactions authenticated?

Joan Van Loon : You had verification is basically that is what happens through the different parties in the transaction. So if you have a transaction, for instance, let me use a healthcare. So so a doctor prescribes the drug and a pharmacist has to deliver the drug to the patient. So you have the doctor, you have the pharmacist, then you have the patient. And these three parties, they are able to validate if the patient at the end, the product he got delivered. He can go back to the first step and see that that is really what the doctor prescribed and then the pharmacist provides, so he is in the middle. He provides the product so he can check also what the doctor prescribed and what the patient has gotten. And then from the pharmacist, again, links them back to the pharmaceutical company to see what product he got in the store and his inventory. So every party in the transaction in the chain can validate the transaction, that's the way it works. And since all the data is stored permanently, you can always go back and audit everything. So everything is basically auditable because everything is stored and everyone in the process has access to that validation.

Meriyem : OK, makes sense. And how is this access defined, granted and executed?

Joan Van Loon : That is between the parties and between the parties in the process. So if the pharmacist prescribes something for certain patient, so in the process you have the doctor, the pharmacist and the patient and they give access. The doctor gives access to the pharmacist to read the prescription. The pharmacist gives access to the patient to get the product. And the patient has access to the doctor to know what he described. So it is arranged by the people in the process of people in the transaction. They define who gets what access and how it's executed.

Meriyem : But then the way you are talking is like you think that within the health care sector, it's better to use a consortium blockchain instead of a public blockchain?

Joan Van Loon : Every blockchain basically starts like that. So when you talk about the public blockchain, you probably think about things like virtual money, the Bitcoin situation. So what we see in block change these days is it starts by a consortium, for instance, there's a very large on container, C containers. So mars is a big container organization. They are the centre of the blockchain. And they set up this blockchain and the consortium of all the parties that they work with. So in health care, for instance, you could imagine that a hospital sets up a blockchain with all their suppliers, all the doctors they work with, with their patient networks, with the patient and things like that. And that is the blockchain, which then can be connected with a blockchain of another hospital. That doesn't matter. So it always starts from a consortium perspective and certainly in health care. And that's also the reason why today you do not find many blockchain in healthcare and health care rather than mean more hospital sector, because you will have examples in pharmaceuticals, in health care, it's more difficult because. Who's going to be the owner who will start this up? Is there a network of hospitals that work together and say we're

going to set up a blockchain and make sure that the process is there? So we haven't seen that yet happening in Belgium.

Meriyem : And do not you think that maybe like, for example, in the future, as AI needs to be trained and needs a lot of data, you can maybe provide data through blockchain because and ensure that the data are transparent, consistent and stuff like this. For example, if we want to train a machine that will be able to do a diagnosis, with all the data from all around the world, you will have more data if you take data from the U.S, Europe and then you will be able to train your machine faster and with better data. So do not you think that maybe then in the future with that technology, blockchain will help AI in that way?

Joan Van Loon : Yeah, no, but like I said, I think that there are elements of A.I. that can help reinforce the blockchain, but you do not need AI to have a sufficient or an efficient blockchain or vice versa. So it's two completely different technologies and AI, as a concept can help you, but the blockchain is really about managing a transaction, managing transactions between different parties. And of course, there's data in there. And with AI you could explore the data faster. You could discover new elements in the data. You could improve the interaction between the data. But you can also do that outside the blockchain. The both are not linked. And there might be use cases where AI can help reinforce the blockchain, like, for instance, in quicker and automatically analysing and auditing the data and auditing all the transactions and trying to find whatever there has been an attempt to tamper. There, it could help. But for health care specifically, the way we use A.I. in health care is completely outside the blockchain story. So there's no direct link whatsoever.

Meriyem : So you think that it's completely wrong and the articles that I would like to optimistic or they didn't get actually what you can do with technology?

Joan Van Loon : No, no, it's not wrong. And it's certainly not optimistic. So the only the only additional thing, so whatever you've been saying about cardiovascular, analysing data and analysing a lot of data that is possible today, I mean, that has nothing to do with having a blockchain or not. I can imagine that to be sure that the data you use in your area is secure is of good quality and remains anonymous, and whatever you want to trust, it's how you could put your blockchain beneath the A.I. But today, I mean, if for instance, the U.S. and Europe and the hospital in Asia wants to work together on finding new cures for cardiovascular disease and they decide to share their data and to share their databases, they do not necessarily need to blockchain to do that. They can do that now and then. But it will be kind of like monolithic databases and so from these monolithic databases, you can control the identity and access management on the monoliths, that's logical. You can share the data and AI uses the data to do its research. What blockchain would add on that additionally, would be if you also take into account all the real time changes to the data. Because then you have the process, then you create a chain between the monolithic blocks on the base, so which means that the data that's fed into your AI is also operationally constantly changing and followed up. And that's the main advantage that I see of a blockchain below AI. So you can have then better security. You can make sure that every transaction in real time gets added to the data. But today, our AI systems are not so far that they can react immediately to changes in information. So when you research, for instance, for cardiovascular, you base yourself on the large blocks of information that are available, that have been validated and that have been controlled. And based on that, you

do your research or you let your A.I. do the research and try to find combinations in the data and try to find information through the data. Whenever a new patient is added to the system, it doesn't automatically get into that algorithmic process. We're not that far, so we cannot say like every new patient is added and it's added to the equation into the algorithm because you have to set up your algorithm and it doesn't go really in real time. So that way we're still far from where we are today. So when we talk about A.I. today and again, it's not specifically health care, we talk about narrow A.I., which means that we are possible, we have the possibility to do natural language processing. So reading text, video images even already for a large part and analysing these. And we can do some machine learning, which is also part of ISO, where the machine kind like quicker assembles the data and can make quicker things out, decisions out of it than humans can. This is where we are. We are far from the A.I. that really

Meriyem : And how would you define AI?

Joan Van Loon : AI is the technology that can help you find new knowledge in information and data, and this means this goes a step further than what we call traditional analytics, because traditional analytics is about data looking into the data and trying to find information from the data or results from the data. AI go one step further. It creates new information, new ideas. So that's the main thing. And if you look at A.I. from the perspective of a human brain, the ultimate goal has always been to replicate the human brain into AI technology. And if you simplify it, you have the left part of the human brain. This is where we do analytics. This is where we read text and stuff like that. So this is where we do natural language processing. Then you have the right side of the brain, which generally is about the emotion. So where we see, where we hear, where we smell, where we feel. And then you have the brainstem, which is mainly about personality and then and emotions. The last one is emotion. And where are we today with I basically on the left side of the brain. So A.I. today is what we call narrow A.I., which means that it helps to do natural language processing so it can read documents, it can congest information, bring it together, find new insights, correlate things in information just like we do with humans. It can do machine learning. So by getting more information, it can get more insights about information and therefore learn quicker than what humans could do and it can interpret data not only from text perspective, but unstructured and unstructured data. So this means also speech documents. This means also video, this means images, things like that. So this is where we are. So the analytical, natural language processing machine learning part. If we look at it at the sensors, so computers that are able to smell, to see, to hear, to taste that is for a part also already there. So there are already some research developments of computers that are able to to smell certain circumstances that are able to hear to see things like that. And but when we talk about the brain stem and about the emotions, we are far from there. So AI at this point is narrow AI and mainly most applications, which we see today are with regard to natural language processing. And why do we use it today? Basically for three things. One is to support decisions, so decisions with more confidence. So based on all this information, we can help humans to make better decisions. The second thing is about the interaction between human and machine. So everything which is also linked to what we call Iot devices, kind of like interact with humans and they take data from the human and send it to another machine for analysis. Think about sensors, think about even Chip's brain chips that are implanted in the brain and that can help control the neurons of humans. So for decision, for interaction and then basically for discovery, which means that it is also applied to find new insights. Let me

take an example in the pharmaceutical industry. So looking for a new drug, for instance, now with covid looking for a new vaccine, we're using AI technology or we providing companies, pharmaceutical companies with AI technology to go through all the data that's out there, all the data that's ever been written about a virus or this specific virus or a related virus and try to bring that data together and try to find combinations, insights in the data that could help the researchers to be more focused in what they research and for finding a cure or for finding a diagnostic tool or things like that. So these are the three ways that the data is being used today.

Meriyem : OK, and what about the challenges that AI is currently facing in terms of technological and ethical issues?

Joan Van Loon : Yeah, so it's the main challenges are around bias, which means that in the beginning it was said, well, AI is better than humans because computers are not biased. And where humans are, we found that that is no longer the reality. So also computers, also A.I. is biased. And the reason why it's biased is for two reasons. One is that data in itself might be biased. And so we had the use case, for instance, in in the US where AI was used to help judges make right decisions. And by default, people from a certain ethical backgrounds were more prone to be seen as perpetrators than others. And why was this? Because in the past there was much more data for that specific group. Therefore, the tool used that data and also so the quality of the data and the bias that's in the data needs to be removed. But the second thing is that humans themselves are still biased and it's humans that basically programmed the system. So if you programmed the system and the algorithms and you always start to self-learning, it's a machine learning, but it starts somewhere. If you program it starting from a bias and the entire system will just extrapolate that bias an aggregated bias and everything it does. So that was one of the big challenges. And this is why we started the global program to have as much diverse and different information so that you can remove the bias. So, for instance, if you talk about face recognition that you are able to feed the system, which is much more difficult, ethnical and colour type of people, so that you remove the bias by having more data. So that's one thing bias. The second thing is about trust and transparency. So and certainly in certain areas, like, for instance, health care, and this is this is crucial. You cannot let a system tell a doctor what the right diagnosis is or what the right treatment is without being transparent on how you come to that conclusion. And a lot of AI systems that have been built. Are these kind of black boxes, so it there's nowhere that they describe on what information does it use? How does it use the information, how those processes, the information and how does it come to a conclusion? It just puts you put in a question and you get an answer, but the process in between is a black box. Yes. So that transparency is needed to have people have trust in A.I. So for a doctor to be able to say, yes, I'm going to follow this decision, I'm going to follow this advice, he needs or she needs to know. The big headlines, how the system came to that advice and of course we use AI because the human brain is limited and A.I. helps us to be faster to process more information, so it is there because we can't cope with that. So you build an algorithm to have that complex process running automatically. And what you are now trying to do with transparency is trying to explain the process to the human again. So that's where we're looking for different steps in the full process. So you do not have to explain the full algorithm, but you have to be clear, how do you get the full steps? And most of the time this is by visuals, how you get from the question to the answer and what is the process in between? So the trust and transparency is a very crucial thing. And this also relates directly to the data. Can the

data be trusted? Is the data ethical? And again, that depends on the quality of the data that depends on the source of the data. So this is something which we now see worldwide going on. A lot of effort being put into ethical transparency and data trust. Also on the European Commission is working on that to make sure that the AI systems they derive decisions.

Meriyem : And about that about the trust and transparency and also the bias. I was reading in the literature review that it was possible to reduce the bias and to increase the trust and transparency with blockchain. What is your opinion about that?

Joan Van Loon : In a way, so blockchain, like I said last time, blockchain is kind of like a ledger, it's a process, it's kind of like different steps in a process which are automated and you always know where the data comes from, who has approved the data, who has done what with the data. So in that context, so if you talk about having quality of data, checking the source of the data, of course, that blockchain can help it because it can fully validate the process of where does the data come from. Who has who has worked with the data, who exchange the data, what is the quality of the data? So that is a way where blockchain can help with regard to trust in a way also because if one part of the trust is knowing where the data comes from and knowing how the AI comes to a certain conclusion, then it can also help, but it will not be able to help with the trust in the decision process as such. Because the transparency that you want to create, so coming away from the black box principle has nothing to do with the process as such, but has more to do with the description and the openness of developers to show how they have developed. So there's a step before the blockchain part. So you first need to open up the system and then blockchain can help to validate what you're claiming in your transparency is true, but Blockchain will not help to open up the transparency as such. Yeah, I do not know if I make myself clear.

Meriyem : It's clear. OK, so the data, if there are more trust, if we can trust the data, then it can help to reduce the bias as well?

Joan Van Loon : Yeah, well also not a bias as such. It can help indeed validate where the data comes from and if the data is again is correct and of right quality. But the bias as such will only be removed by by having more data. So blockchain in itself will not remove the bias. So the process to remove the bias is a process of making sure that you use enough data to come to the right conclusion.

Meriyem : A question was about the accessibility of data. So blockchain cannot increase the accessibility to data or you think that they can do like for example, if now we do not have enough data about people in the developing countries. Let's imagine that they have the right over their own data by owning them. And then they can maybe share it in exchange of money, for example, and then maybe put the data in a more centralized way. And AI can have access to more data that normally he wouldn't have.

Joan Van Loon : Yeah, yeah, again, that indeed is a possibility, and again, the more data you have, the better. So in that way, the more access you have to data, the better for your

AI system. But of course, blockchain is not what will control if people will give access and if you have access. But once the access is given, then blockchain can manage the process behind it and making sure that the new data that comes in comes from the right source and is validated then and whatsoever. But for instance, take the Belgian situation here in Belgium, if you look at healthcare data, this is basically, this is in the hospital, this is where the general practitioner, some of the data is with the insurance, some of the data is with private insurers and whatever. So the data is really spread in different silos. So blockchain as such will not open those silos. But if the owners of the silos decide to give access to their data and to open up their data for everyone, then blockchain indeed could be an enabler for them to make sure that they know who will use their data, what they're used for and where they're going to. So it basically enables, it gives a more secure and safe and controlled environment to be able to open your data. But of course, if only two people or three people or three companies decide to create a blockchain, the data will still be remaining for those three companies. If there are 100 companies willing to do that, then of course, you have a different story. So what we see, for instance, we have built a blockchain for banking, the wheat trade. I do not know if you heard about that, but this is about banks wanting to share their information on a blockchain platform. If you do that with two banks and that works fine for the two banks. But the major advantage is if you can do that with all the banks in Belgium. So blockchain again helped them to say, OK, we have now a secure ledger, a secure infrastructure where all the operations and all the data are exchanged but also controlled. And it depends on who has access to which data and what. So by having the blockchain, more banks are interested to step into the process because they know the process is secure. So it's the same with health care.

Meriyem : OK, right. And by using this system, it can also increase the trust that the patients will have in a decision because according to some study users, I mean, patients or you and me won't be eager to trust a decision made by a machine. Can it help to increase if we say that we have more data and we have safe data behind, so there is more chance that the AI is well trained and that it provides better decisions. So you can trust it actually. Can it help or it won't help to solve that problem of trust in AI machine?

Joan Van Loon : It won't completely solve the problem. It will help in a bit just for the aspect of knowing where the data comes from, knowing that it's qualitative data and knowing that it has not been tampered with. So for that aspect, yes, but it won't help with the process of trusting the fact that the machine has gone through all the data and can't come up with an outcome because basically blockchain does not control that outcome. Blockchain is it controls the process, controls where the data comes from, but it does not control the algorithm, the machine learning as such that is not what blockchain can do. So you have to have a certain trust in the fact that, well, the machine used this information and comes out with this outcome because combining all these different studies, all these different information, all these different evidences, this is the best outcome. But it will never be able to fully, completely trust that if you do not trust it. I mean, the comparison is always like you go to a physical doctor, to your GP and he or she takes a decision. And you as a patient, you trust that decision or you do not, but most people trust the decision because it's the doctor, right? Yeah, but the doctor does not have all the information either. And maybe this is sometimes gut feeling because in health care, not all the answers are there. We do not have an answer for every problem. We do not have a treatment for every disease. We do not have a diagnosis for every disease. So there's a lot of things we do not we do not know. So that's why we use these artificial

intelligences to discover new insights. Now, these are new insights that were not discovered by the doctor and cannot be discovered by the doctor or the researchers or the pharmaceutical industry or whatever. So the fact that the machines comes up with that answer. If you want to trust that answer yet, you need to trust somewhere the technology behind it.

Meriyem : Yes it makes sense.

Joan Van Loon : And again, we've done this study where you see that people trust a doctor more and a machine even when the doctor makes 50 percent errors and the machine only two percent errors. So the way we look at machines is that we expect them to be 100 percent correct. And for a doctor or for a human, we expect them to make mistakes. We do not expect them to know everything. And that is the big difference.

Meriyem : Yeah, Now, I mean, I will say that from its I mean, it will it has been now it's an example. Ten years that I'm using blockchain that I am my data are protected and untampered through blockchain and my doctor will have access to all my historical information. So maybe it can help to do a better diagnosis for example, because from now, I mean if we go to one doctor to another, it cannot have all the information, he does know it doesn't know what the other doctor has said and so on. So if now over time, more people are using a blockchain to store and share information, I mean, in a decentralized way, and to have all the information from ten years ago, can it help the machine to do a better diagnosis based on every information and not only on the few information that are known?

Joan Van Loon : There's three different aspects to that question. So, one is you do not need blockchain to do that. The fact that the information is now in silos and that your doctor does not see all the information and then some is there and there and there, that can purely be solved by having an interoperability process, giving access to the data and making sure you share the data on a common platform. So you do not need blockchain to do that. You can do that with other technologies, blockchain can help you make that more secure and auditable and so on and so forth. OK, but as such you do not need blockchain for that. The second thing is that the doctor.

Joan Van Loon : Will not be able to make better decisions, per say, because there will be so much data, he and she cannot cope with the data. They are not capable of reading all the data then making the right conclusions and then then making the right decisions. So this is why we have AI. Because AI can cope with much more data. It can be quicker and faster, analyse the data, bring it together and come with the answer. That's exactly why we do it. But in the context of health care, the way we look at it is the final decision. That was one of your questions Also, by the way, the final decision remains with the human. So it's not the machine that takes the decision. It is the machine that analyses the data that comes up with the best suggestion and mainly most of the time suggestions, because if there's not a black and white answer, it has to give you like confidentiality levels, like saying, OK, with the information I have now about this patient, this treatment is the best. This might be another good alternative and this might be a third alternative. And the first one, I'm 80 percent sure, the second bomb, 20, and the third one, 10 percent. It's a bit like that's how it works. But it's finally still the doctor who decides which of the three options he or she will implement. Depending on his or her experience, but also on the answer that

the machine gives and the information that's behind it, that's why I said that we are trying to visualize and trying to make the complex algorithms clear with certain milestones so that if a doctor gets these three options and he sees option A is according to all the data, 80 percent confidence, So the best. So he can still or she can still look like how does this machine, how does this AI technology now come to this conclusion and why does it provide option A? Option B?

Joan Van Loon : Yeah, and that's the way it works today. So the final decision remains with the human. And that's also why we refer to it as augmented intelligence rather than artificial intelligence, because it augments the human decision making process. And the machine human interaction for us is crucial. So this is not about a stand-alone machine. And like I said, far from there, that that is really science fiction. So it's really about helping the humans interact in a better way and helping the technology to do things which are human cannot do himself, which means reading thousands of documents every day, assimilating all the new information every day, putting the dots together every day. So that is where the machine helps.

Meriyem : OK, ok. Makes sense. And about the when you answered the survey that I did, you said that blockchain can help AI with governance, legal and regulation. Can you elaborate on this, please?

Joan Van Loon : Yeah, because that's basically what, so blockchain manages the process. So the governance of the process of knowing where the data come from, who has sent which data to whom, who has who has changed the data, who has added data and things like that. So the full governance of the data between, for instance, a hospital and a patient and a doctor, that that's where Lockton works perfectly. Legally also to indeed have an auditable trace and an audible tracking of where the data comes from. So if you have your final answer, you can auditability track like, what data, what information has been used to come to that answer? Where does this data come from? Who has provided the data? What is the source of the data? What is the quality of the data? So in that way, it can also help the legal process.

Meriyem : Can it help with the responsibility and liability issue? About the decision made by your machine or absolutely not?

Joan Van Loon : It depends, I mean, the responsibility of the men who took the final decision.

Meriyem : Yeah, because if at the end the doctors take the decision, he will be responsible for his action?

Joan Van Loon : Yes, so the machine is the machine is never responsible and the doctor will never be able to claim yet well, I took this decision, but the machine was wrong. I mean, that's not the way it works. That's not the way it's set up. That's also why that the final element in it will remain in human decision supported by underlying information. But I mean, again, this is what most of the time has been discussed here. But then the doctor trusts the machine and then the machine might be wrong. OK, but what does the doctor trust? Does he trust his or her gut feeling or an article they've read or the experience of a colleague? So again, now they will trust a source of information which uses

much more information so which goes much broader, which basically includes everything which is possible to include with even the way to check on how it got there. So we're way further than today where a doctor read an article about a certain drug and reads that drug is good for that kind of disease. I will prescribe the drug. So also then as a patient, if the doctor prescribes the drug, you're not going to ask, like, why do you prescribe this or have you read this? Can you prove that this drug is the best for me?

Meriyem : Yeah sure. But then over data, I think it's over. I also read about the fact that with blockchain, we can create decentralized computing power?

Meriyem : Were saying that if you have to run AI models for little companies, for example, as the competing powers will be decentralized. Is it possible?

Joan Van Loon : Yeah. The decentralized bit is the fact that data can remain in their source. So in the past, for instance, when let's take a simple example is this four hospitals and those four hospitals want to work together. They all have their databases. Let's say all four have one database. If you want to put them together, you needed to create a new database, which basically then used all the information from the four database. And in the case, you basically created your overall process, your overall decision process, whatever, with distributed computing, this is no longer needed. So you can leave the data in the four separate databases and the AI technology is a layer on top of it which does not need to duplicate all the data into one new database. It just takes out the data from the four underlying databases at the moment it needs to and with the purpose it needs it for. So this is the reason why it can go much quicker. And also this means that the smaller organizations of each of the hospitals on their own can build an AI system based on their data and then using data from other hospitals or from scientific literature or whatever to do their own developments. So this is what you, for instance, see in the pharmaceutical. Let's think again covid. Let's take trying to find a vaccine for covid. So different pharmaceutical companies are doing that. All these companies have their own data from past research, from current research, from experience data, they bought things like that. So that's their own data. That's their IP. That's their stronghold, because that's so far for them. So that's something you do not want to give away like that. But on the other hand, they need data from patients around the world, test data, about disease and things like that. So this is what they get. So they built their A.I. system on their own set of data, incorporating data from other organizations, generically available data, data from patients, from conferences, a database with all the patient data which has been used by all the other pharmaceutical companies. So this is the reason of this distributed computing, and this is why it makes it possible for smaller organization to indeed also take the advantages of A.I. without having to build a big A.I. system which has access to all the data. And one of the ways AI set up today is what we call APIs. So these are basically building blocks, legal building blocks, and they all have small parts of what and AI system can do for instance, natural language processing, text to speech, speech to text. So all these different components that if you put them all together, you have a big AI system, but all these different components are made available. So smaller companies can, for developing AI solutions, use those components they need without again having to build that one big massive A.I. computer system.

Meriyem : OK, makes sense, it's clear. And do you think about another context in which

blockchain can help AI? Now we talked about the data and a decentralized computing power. Do you think about another way these two can merge?

Joan Van Loon : No, what we said about data to the state with regard to do some of the operational legal process, auditability aspects that's it I think. Blockchain for me really is about managing and governing a process. AI is more about trying to find new insights, trying to find new information, trying to develop new solutions based on data.

Meriyem : Ok. And about what we were talking, do you think that there is there will be issues in the future or if application already exists to make these two together?

Joan Van Loon : Well, the main the main issue is about, like I said, you first need to process you first need the different parties to agree on how to work together. And that is the main issue, certainly in health care and certainly in Belgium. So today, all this data is still distributed, then spread and is not being shared. So the accessibility to the data and then the next step is, of course, checking the quality of the data. Somebody needs to start and own that process. And this is something which is not happening today. So as long as there is no will to share data, to set up a blockchain and of course, the blockchain will have will have no value.

Meriyem : Okay. But I think that we can go to the model, the last part. So basically it's to see if a model can be accepted either by a population, by professionals who are going to use it or not. So it tackles the perceived usefulness, the perceived ease of use, the attitude towards using the system, the behavioural intention to use it. The first question is about integration. So would you the integration of these systems, according to you, in enhance AI and the users' job performance and does it seem useful?

Joan Van Loon : Well, I do not think it will by definition improve the user's job performance. I think it will improve the developer's job performance and the ones developing and designing the AI applications. So the end user is not interested in the process. So as long as the answer is quick and is there, it's not the end user that the performance will increase by having auditability or hold data and by having all the quality of the data, they just want the right answer at the right time.

Meriyem : OK. And would it be easy to use and to implement?

Joan Van Loon : At technology wise, yes, process wise and legal wise in Belgium, no.

Meriyem : OK, and do you think that blockchain use in AI is understandable and clear or not yet?

Joan Van Loon : Well, it depends who you talk to, I guess. I think not for the general population, because if I talk to a lot of people in the industry there, they are not aware of. they all know something about it, but if they find it still difficult to define the right use case. And for me, understanding is about being able to define your use case because otherwise you have the technology. Technology is there. You do not need to understand all the technology in detail, but you need to know what to use it for and why to use it. And that seems to be still a big struggle. So I do not think they fully understand what the capabilities are and what the possibilities are and then translate it into a real use case.

Meriyem : So do you think that before this implementation we should improve the literacy of people about the technology?

Joan Van Loon : Yes sure! For blockchain and AI. A lot of people talk about AI, but if you really look what they're talking about, it's not AI, it's analytics, it's robotics. And that's not AI so even there is still a lot of literacy missing. But again, the literacy is missing. And then also the full overview of what is required to do it, because you need to know what the potentials are of AI and blockchain. And then you need to understand what is needed to reach that potential. And then you need to understand what you need to do to give the access to the data, to open the data, to provide data with great quality and so on and so forth. So there's a lot of things but it's all about the need understanding the full picture.

Meriyem : And now at the end, you were saying that sometimes blockchain is not the only to resolve one of the issues we tackled. But what is your feeling and your impression about the implementation of these two? Would you rather go for saying that there is other solution than blockchain?

Joan Van Loon : Well, I think they both have a purpose and a business case. And like we talked, there is a purpose and a business case for putting both together, but both could also perfectly exist, walk next to the other, serving their own purpose. So so, for instance, if you want to solve the issue of auditability, OK, then you can do that with blockchain and you do not necessarily need AI. If you really want to go for finding new cures, for finding new diagnostics, for finding new treatments for diseases, then AI can help you there without needing blockchain. So again, both can and strengthen each other through the auditability process and so on and so forth to managing the process and the governance. But they are not needed to have positive effects from blockchain or for AI so they can have the positive effect without going together.

Meriyem : OK. The next question, you kind of answered it, it was what would you be your attitude toward is would you go for it but you answered it. And the last one is, do you think that in the future these two have the potential and a high probability to end up together?

Joan Van Loon : Medium, both have potential and probability, I think it's already difficult to work with one of them and it will be even more difficult to put both together. So again, if there is the right use case and in certain circumstances and for certain things, it will be done. Because it has the best potential. But in general, I think probability will be low and they will be put together. Because if I really to be honest, if I look today in the Belgian market and the cross industry, if you look at blockchain, there are people really struggle to find use cases for blockchain, while on the other hand, they do not struggle that much to find use cases for AI. So if you want to put both together, I have a bit of feeling that blockchain might slow down the advantages and the evolution of A.I. rather than speed up.

Meriyem : OK. So maybe in the long run or not at all.

Joan Van Loon : I think and again, it depends on what is what is the main priority if indeed it spins out, that it is more about data governance and auditability and traceability. Then yes, it will be needed and then they will need to be put together. If the priority is more about finding solutions fast and better fail fast than wait for the long term real solution,

then blockchain won't have that much value for AI. So, it depends on what is highest on the agenda, the security governance story or indeed finding new solutions and then coming up with new answers. So this is a bit like again, if you take today the development of the vaccine for covid. So in normal times, it takes about 12 to 14 years before a new pharmaceutical product is on the market. Because there's an entire process of 12 to 14 years of testing, proving whatever. So there's a lot of things that needs to be done. And that blockchain can help because it can help kind of like put that full process of testing approvals and everything and manage that perfectly, but it won't speed up those 10 or 12 years. And the fact that they're now looking at a vaccine and then trying to find something in two years that has nothing to do with the knowledge and the information that's out there that has everything to do with the fact that we cut out a lot of processes, a lot of checks just because we need the vaccine as soon as possible. And that's the difference. And so for the second thing A.I. is more relevant because then you can have more analysis or more data and be much quicker than what you would normally do. But blockchain would be a kind of like would slow it down, because then you are indeed with the process of checking, auditing and whatever. That's a bit the way I look at it.

Meriyem : It makes sense. Thank you for your time and your participation.

Joan Van Loon : With pleasure, bye

Meriyem : Bye

Interview Daniel Yasri

Meriyem : Bonjour, vous allez bien?

Daniel Yasri : Ca va et toi?

Meriyem : ça va, merci beaucoup. Tout d'abord, avant de commencer, m'autorisez-vous à enregistrer le call à des fins académiques et à utiliser les informations pour ma recherche exploratoire ?

Daniel Yasri : Bien sûr, pas de problème.

Meriyem : Merci beaucoup. Je vais me présenter brièvement. Je m'appelle Meriyem, je suis étudiante en 2^e année de master en ingénieur de gestion en Belgique et je termine ma dernière année avec un mémoire concernant la blockchain et l'AI avec plus précisément pour question : *"Can the blockchain technology mitigate some of the perceived risks related to Artificial Intelligence?"*.

Daniel Yasri : Bravo d'avoir choisis un sujet aussi passionnant et un sujet de l'avenir. Qu'est ce qui t'a guidé vers ce sujet ?

Meriyem : C'est mon promoteur qui m'a proposé le sujet et ayant eu un cours de télécommunication ou on a parlé de la blockchain en 2^e année de bachelier et que cela m'avait intéressée, j'ai accepté.

Daniel Yasri : D'accord, c'est intéressant. Il y a un article que j'ai écrit sur la blockchain et les smart contracts, ça pourrait t'aider peut-être. Et c'est dans healthcare. J'ai écrit plusieurs articles, je vais t'envoyer, ça peut t'intéresser. Mais tu t'es lancé un sacré challenge Meriyem.

Meriyem : Oui j'en suis bien consciente. Mais c'est intéressant.

Daniel Yasri : Exactement

Meriyem : Peut-être qu'on pourrait commencer avec votre présentation brièvement et m'expliquer également votre lien avec la blockchain et l'AI ?

Daniel Yasri : Alors, moi je suis dans la blockchain depuis 2011 ou j'ai appris via les crypto monnaie, j'ai trouvé le concept incroyable, puis j'ai trouvé le concept de blockchain incroyable. J'ai toujours voulu faire des études de médecine mais je me suis toujours dit que je ferai autre chose à côté. Donc du coup, dès que j'ai pu passer mon internat, après 6ans, je suis devenu interne. Et dès que je suis devenu interne en médecine, j'ai lancé 2 boîtes, une boîte de consulting indépendante qui avait pour but de travailler dans tout ce qui était blockchain à la base et puis j'ai beaucoup plus percé dans le côté healthcare parce que les gens écoutent beaucoup plus quelqu'un qui est médecin que quelqu'un qui ne l'est pas dans le domaine de la santé. Et alors, une autre boîte filchain. J'ai travaillé avec Kori Léon qui est pharmacien. Et ça marchait très bien, dans les événements où se dire qu'un pharmacien et un médecin parle de la blockchain pour la santé ben c'est le top du top. Je compte également lancer un projet de data management de patients. Concernant l'AI, j'en

connais énormément sur le sujet, mes meilleurs amis travaillent dans l'AI, tout ce qui est machine learning, deep learning et pour moi c'est l'avenir et j'aime tout ce qui est en lien avec l'avenir.

Meriyem : D'accord, super, merci. On peut commencer avec les questions la blockchain. Comment définiriez-vous la blockchain ?

Daniel Yasri : Alors pour moi, la blockchain déjà c'est un registre, c'est la base, de la base, de la base, il faut comprendre que la blockchain c'est un registre. Et à travers ce registre, c'est un registre sécurisé qui est immuable et qui la possibilité surtout d'être transparent. Et ça c'est quelque chose qu'on avait jamais vu avant. Donc, c'est un grand registre immense qui est décentralisé parmi les trois mots clés, sécurisés et plus ou moins transparents.

Meriyem : Vous entendez quoi par plus ou moins transparent ?

Daniel Yasri : En fait, c'est là, il y a différents types de blockchain, comme tu le sais à mon avis, les blockchain publiques, Bitcoin, Ethereum, les blockchain semi-publique sur lesquelles, par exemple, il faut s'inscrire pour avoir une clé privée et avoir le droit d'être dessus. Donc, ça veut dire que là, tu mets des informations à toi. C'est comme s'inscrire sur un site internet, mais tu peux ensuite avoir le droit d'avoir accès à cette blockchain alors que le bitcoin tout le monde peut y accéder, tu n'as pas besoin d'avoir accès, tu n'as pas de zone d'accès, tout simplement. Puis tu as les blockchain privée qui demande vraiment de faire partie d'une entreprise, etc. Ou de vouloir intégrer un produit que j'appelle transparent ou pas. Et ça se retrouve même entre guillemets, la notion de transparence va pour moi bien plus loin que la notion de public privé ou semi-public. C'est qu'il y a des blockchain public comme Monéro qui ne sont pas transparentes sur certains points. Par exemple, si tu connais le Monéro, c'est la monnaie pour le transfert d'argent caché. En fait, ça veut dire que, donc, dans le bitcoin, si tu me donne ton adresse bitcoin. Je vais dans l'explorer bitcoin. Je peux voir le nombre de bitcoins que tu as, on est d'accord soit si tu me donnes une adresse qui est sur la même clé privée. Tu me donnes un numéro transaction. Si Meriyem envoie de l'argent à Daniel et que quelqu'un a le numéro de transaction, je fais tiens Meriyem elle a envoyé de l'argent, regarde ça. Tu ne me crois pas, regarde, je te montre le numéro transaction, la transaction ID je rentre dans mon blockchain explorer. Je vois bien que telle ou telle adresse à envoyer à telle adresse, je vois le nombre de bitcoin. Le monéro, c'est une blockchain, par exemple, ou tu ne vois pas du tout qui a envoyé à qui ni combien. Mais tu sais que la transaction existe, par exemple. Ça, c'est ultra intéressant, ça permet plein d'usages différents et c'est ce qu'on appelle les blockchain moins transparentes. La blockchain c'est du hash aussi. Tout ce qui est blockchain passe par une fonction de hachage. Tu sais ce que c'est le hachage, je suppose. Et pourquoi c'est génial ? C'est génial parce que la plupart des objets marchent en SHA 256 et comme tu sais, SHA 256, ça permet de condenser des choses en une série de caractères. Comment dire ça, sans risque, avec un risque de collusion qui est vraiment minime, de chez minime. Je ne sais pas si tu sais de quoi je parle ou pas.

Meriyem : Le risque de collision, pas trop, non.

Daniel Yasri : A mon avis, c'est un concept, ultra important de la blockchain. Tu vois mon écran la normalement. Donc, le sha 256, ça permet de condenser quelque chose en Hash.

Donc du coup, si tu tapes par exemple blockchain. Le hash de Blockchain, c'est ça. Sur une clé de 64 caractères. Quand je te parle de risque de collusion, je vais te montrer, si je prends, par exemple, si je prends l'article Wikipédia de la blockchain. Et que Je prends un paragraphe entier comme ça, j'ai un autre hash. Il y a peu de gens qui croient, mais cet hash est exactement égal à ce texte, mais à rien d'autre dans le monde. Avec le 256 Les risques de collusion sont extrêmement, extrêmement faibles et d'ailleurs on est passé au sha 512 maintenant parce que pour être encore plus sûrs. Mais les risques de collusion dans le sha 256, en fait, ça serait le risque qu'un un autre truc soit égal à ça. Par exemple, c'est assez impressionnant, genre si je tire un point, tu vois à quel point tout change. Ça n'a rien à voir. Et ça, c'est la base de la blockchain aussi. C'est que grâce à ça, c'est comme ça qu'on a ce qu'on appelle la sécurité asymétrique. Ça veut dire quoi? Ça veut dire que si je te donne ça, un jour, je te renvoie, je te dis tiens Meriyem, si je te le donne comme ça, tu ne peux pas lire. On est d'accord, juste parlant en message comme ça, tu vas me dire je ne comprends rien. Mais en fait, ce n'est pas ça le but de la blockchain Et c'est pas ça le but du Hash. C'est ça qui est très fort. Le but, c'est que si je te donne ça, tu peux vérifier que quand je t'ai envoyé ça, c'est bien égal en effet à ça. C'est ça qui est important. Le seul moyen de lire ce message, c'est de connaître le message d'avant. Donc, si je te dis je t'ai envoyé un message ou il est marqué : La blockchain c'est génial. Et toi, tu fais, tu regardes, tu dis ah j'ai taper la blockchain c'est génial, je n'ai pas la même chose. Je te dis : t'as mis un « e » à la fin? Je n'ai pas mis de « e ». Tu retombes sur le même truc que moi. En effet, c'est bien ça et c'est cette fonction de vérification qui est ultra importante dans la blockchain en fait. C'est vraiment ce qu'on appelle la confiance asymétrique, c'est à dire que si tu ne sais pas le début, en fait, avant la fin ne sert à rien et c'est ça qui est magnifique, c'est que tu peux justement hashé des trucs. Et si tu as l'information de base, tu peux vérifier ça. Ce qui permet cette sécurisation et cette transparence, en fait. Si tu connais le message de base, tu as juste à vérifier pour être sûr que c'est bien ce qu'on a envoyé. Quel intérêt ça a du coup? Ce sont des algorithmes qui rétablissent la confiance. C'est la confiance qu'on veut dans la blockchain. C'est ça. Moi, je veux savoir que si mon médecin, il a dit que j'avais du diabète, si je reçois ce truc là-bas, c'est bien égal au diabète, sur ma blockchain, je veux que ce soit ça. Ça me permet du coup de signer. Tu peux signer via un hash. Tu ne peux pas être le seul à avoir un hash et dire Voilà, moi, j'ai ce hash-là plutôt qu'un mot de passe. Ça sert aussi à vérifier l'intégrité. Parce que si, par exemple, t'as un dossier médical, donc je tape un truc comme ça et là, tu as une anomalie qui arrive qui arrive et je mets un 0, tout change. Et donc tu vas dire non, ce n'est pas mon dossier médical parce que moi, mon dossier médical, c'est ça. Je suis désolé. Mais vous avez une erreur quelque part, par exemple. Et ça, c'est super important aussi. C'est une fonction qu'on appelle à sens unique. Ça veut dire que si tu veux, si tu te rappelles un peu les $f(x)$ et x est introuvable à partir de la fonction F de X . En gros, pour moi, comme je dis souvent, il faut penser à la mayonnaise. Tu peux mettre des œufs, de l'huile et en gros, tu ne pourras jamais si t'as pas la recette, savoir ce que j'ai mis avant. Savoir ce que j'ai mis dans la mayonnaise parce que j'ai fait de la mayonnaise, c'est un hash, c'est hashé, c'est comme ça. Tu ne pourras pas savoir, par contre, si je te montre tous les ingrédients, il y a ça, alors là tu diras Ha oui, en effet, ça colle, ça colle avec ça. C'est ce qui est super important.

Meriyem : Et si maintenant on dit justement qu'un bloc possède un hash, qu'on ne peut pas le modifier parce que si on modifie en partie ce hash là, tous ceux qui suivent et qui avait déjà été créé vont être modifié.

Daniel Yasri : En effet, un bloc du bitcoin, Il a une entête, le hash du bloc précédent, Le nombre de transactions le PoW, c'est le nonce, qu'on appelle, ce qu'il a recherché pour créer ce bloc et son propre hash. Du coup, dans le bloc 7, par exemple, si t'es au bloc 6 , dans le bloc 6 tu as le hash du 5, le PoW du 6, et le hash du bloc 6. Dans le 7 tu vas avoir l'entête du 7, le Hash du Bloc 6, le PoW 7 et le hash du bloc 7. Et ça, du coup, ça fait qu'en effet, c'est immuable parce que si tu changes, justement, c'est ce qui fait que la blockchain est immuable, si tu changes, ne serait-ce que je veux changer, par exemple je veux changer le bloc 6, sont hash va changer parce que en fait le hash du block 6, c'est la somme des transactions en hash. Si tu modifie une transaction, je vais mettre 1000 euros au lieu de 100, tu rajoutes un truc, le hash du bloc 6 va changer et le bloc 7, il va dire ben non, en fait ce bloc, ce n'est pas celui qui vient avant moi, parce que moi, j'ai le hash du bloc 6 avant et ce n'est pas le bon et du coup, tu vas juste te faire rejeter. Tu dois savoir que dans une blockchain, ça ne fonctionne par La majorité, entre guillemets, c'est pour ça qu'on décentralise à travers des nœuds. Donc, il y a si un nœud s'amuse à changer le bloc 6, tout le monde va lui dire ben non, désolé, ce n'est pas ta version de la blockchain qui est vrai.

Meriyem : Vous avez pris l'exemple du bitcoin, mais le hash il est valable pour toute les utilisations? Ca fonctionne de la même manière?

Daniel Yasri : Alors, non, je ne dirai pas tout à fait de la même manière. Ce n'est pas exact. Par contre, que ça fonctionne de la même manière, tout ce qui bloc, il y a toujours le hash du bloc précédent. Le proof of work il n'y est pas pour certain truc. Ce n'est pas des transactions qu'on met aussi. Qui ne fera pas les transactions qu'on met aussi entre les deux. Mais sinon, ça fonctionne toujours le Hash du bloc précédent, hash du propre bloc, hash du bloc précédent, etc, ça permet d'assurer cette continuité. Ce que j'aime bien dire, c'est que personne ne comprend la blockchain. Vraiment, ce n'est pas encore possible de comprendre la blockchain. Parce qu'en fait, c'est trop compliqué. C'est quelque chose qui est tellement technologique que comprendre, ça voudrait dire que tu connais le shah 256, que c'est une encryption militaire. C'est pourquoi c'est irréversible. Tu as bien compris hein c'est irréversible, c'est à dire qu'il ne sait pas craquable. Il n'y a aucun ordinateur au monde qui peut craquer, ça, ça n'existe pas. Si je tape des trucs qui n'existent pas, genre ça, personne ne va trouver que c'est égal à mon message, c'est pas possible actuellement sur Terre. peut-être que quand il y aura des ordinateurs quantiques, on peut commencer à discuter, mais actuellement, ce n'est pas du tout le cas et c'est pour ça qu'on dit que c'est asymétrique, tu ne peux pas revenir en arrière. La complexité de la blockchain est importante. C'est très, très compliqué. Et franchement, j'y suis depuis 2011 donc ça va faire 9 ans et j'en apprend encore tous les jours. Pourtant j'ai lu les plus grands bouquins. Mais voilà, quand tu as lu baston et bitcoin, Franchement, tu comprends, tu comprends le bitcoin, tu connais le bitcoin. Mais voilà, il y a une nouvelle qui sort, il y a Ethereum qui sort, qui amène un degré de complexité extraordinaire par-dessus la blockchain, avec des smart contracts qui ont tout révolutionné. Et qui ont amené des choses énormes. Après il y a Ethereum 2.0, qui est prévue dans les prochains mois. Qu'on appelle le layer 2 pour éviter cette surcharge que connaît actuellement le réseau etherum et qui veut passer en proof of stake. Il y a tellement de choses qui vont tellement vite que c'est impossible de connaître la blockchain. Moi, celui qui me dit je connais la blockchain. Je n'y crois pas. Ce n'est pas possible. Ça, c'est trop vaste. Il faut être humble. "Je suis au courant de la blockchain. Je sais quelques trucs sur la blockchain. Je travaille sur tel domaine dans la blockchain, mais je ne peux pas connaître toute la blockchain ».

Meriyem : Clairement. Mais du coup, là, on a un peu répondu à ma question d'après qui était comment la blockchain fonctionne et qu'est-ce qu'elle peut apporter? Vous en avez déjà parler mais vous avez quelque chose à rajouter ?

Daniel : Oui, bien sûr. J'ai plein de trucs à dire, déjà pour l'instant, pour la santé hein moi je parle, tu parles par rapport à la santé hein?

Meriyem : Oui oui, la santé

Daniel Yasri : On pourrait s'attarder pendant des heures, traçabilité sur tout ce qui est logistique, le système bancaire, mais ce n'est pas ce qui nous intéresse, les données de santé. Alors, sécuriser les données de santé. Mais mon Dieu, qu'est-ce que ça serait le pied si on avait les données de santé sur blockchain. Je travaille actuellement dans un des plus grands hôpitaux de France, à Montpellier, CHU Montpellier. Et si tu sais que toutes nos données patients sont centralisées dans le même serveur, Meriyem. C'est à dire que si un jour, il y a quelqu'un qui s'amuse à le pirater, Il a accès à toutes les données et qui peut tout faire exploser. Ça m'énerve. Quand orange ne marche plus, l'opérateur et qu'on n'a pas accès, on qu'on n'a pas accès à un truc, et qu'on me dit oui en ce moment, il y a un dysfonctionnement parce que le truc est centralisé, il est centralisé. Il faut arrêter de centraliser les données importantes. Ça n'a pas de sens. Ça veut dire avoir un seul point d'attaque pour n'importe quoi. Une seule faille entre guillemets, c'est nul, c'est nul. Tu ne peux pas te permettre, à mon avis de nos jours, et pourtant, c'est ce que les gens font, d'avoir les données de patients et les données de santé, quelles qu'elles soient en fait dans un serveur qui est centralisé. Pourquoi on ne décentralise pas ? Pourquoi il n'y a pas plusieurs copies du même registre ? Et pourquoi ce registre, Il ne serait pas haché ? Justement, ou encodé via la blockchain. Deuxièmement, pour moi, ça permet une interopérabilité des systèmes. Sauf que là, je ne sais pas comment ça marche chez vous en Belgique, mais moi, si je prends mon dossier médical et que je vais chez le médecin, chez mon médecin et que je vais chez le médecin qui est deux villes plus loin, et bien, je lui dis bien vous n'avez qu'à prendre mon dossier de là-bas, c'est pas possible, je ne sais pas comment ça se passe en Belgique mais si tu veux avoir un médecin que tu n'as jamais vu, il n'a pas ton dossier médical. Mets-moi ça, dans une clé privée strictement privée, c'est un hash là, tu donnes ça à ton médecin il la rentre et il voit tout tes trucs, quoi.

Meriyem : Mais justement, par rapport à EMR, ça pourrait fonctionner comment si on introduisait la blockchain ? Vous auriez un exemple, car c'est un exemple qu'ils utilisent beaucoup dans les articles

Daniel Yasri : Tu veux savoir comment ça pourrait marcher ?

Meriyem : Oui, et comment les données pourraient être justement protégées.

Daniel Yasri : Super intéressant. En fait, ça marcherait comme ça, on serait sur une blockchain, ce qu'on appelle de consortium, semi-privé semi-public. On appelle ça comme ça. Une chaine de consortium. Comment ça marcherait. Pour avoir accès à une blockchain et faire, ce qu'on appelle une transaction, on va parler transaction au sens large hein, je ne parle pas de transactions monétaires, d'accord, il faut comprendre que transactions, ça va juste faire un input sur la blockchain. D'accord ? Il suffit de signer un message ou une transaction, un input avec ta clé privée. Ta clé privée, c'est ce qui permet que toi, tu rajoutes des trucs à la blockchain. Tu envoies les trucs, tu envoies de l'argent, tu envoies

un message parce que tu peux envoyer un message via la Blockchain même via la blockchain bitcoin. Et ça, c'est ta clé privée, c'est à dire que c'est quand c'est toi qui veux faire les choses à côté, tu as une clé publique. Une clé publique, c'est quand tu donnes ton adresse aux gens, par exemple pour faire le parallèle avec le bitcoin, mais c'est pareil pour le dossier médical. La clé publique, si tu me la donnes, pour que tu m'envoies de l'argent. La clé publique, tu ne peux rien faire. Si je te donne une clé publique avec laquelle je regarde, mais ce qui n'est absolument pas obligatoire. Et donc avec la clé publique, tu peux juste m'envoyer l'argent. Avec la clé privée, tu as accès à mes fonds, donc accès à mes données patients par exemple et avec la clé publique, tu peux voir mes données patients, mais tu ne peux pas les modifier. Mais ce qui peut être fait aussi, c'est ce qu'on appelle avoir des oracles. Ça, c'est super important. C'est quelque chose que je prêche depuis des années et c'est le plus important. Les oracles sont des gens qui vont certifier les choses. Comment ça marcherait. Toi, j'espère que tu es en bonne santé. C'est tout ce que je te souhaite, mais émettons. Je ne sais pas. Tu as une allergie aux acariens, donc tu te mets allergies, tu as ton petit dossier électronique sur ton portable, allergies aux acariens, c'est toi qui le rentres. Au niveau qualitatif, tu comprends qu'elle a peu de valeur parce que c'est toi qui la rentrée, tu aurais pu mettre allergique au film Spiderman, tu vois, on s'en fou. Ça n'a peu de valeur. Ça a une certaine valeur parce que quand même, tu te connais, si t'es quelqu'un d'assez sérieux, tu ne vas pas mettre n'importe quoi dans ton dossier médical, mais ça a peu de valeur. Donc, avec ta clé privée, tu signes un message, une transaction, comme quoi tu as une allergie aux acariens qui est encodée, du coup dans ta blockchain, donc sur ton profil public. Mais t'aimerais bien quand même que quand tu dis que t'es allergique aux acariens, on te croit vraiment sur parole, tu vois ? Parce que si t'es vraiment allergique aux acariens, c'est ennuyant quoi. Donc tu vas voir ce qu'on appelle un oracle. Un oracle, c'est quelqu'un qui, comme je t'ai dit, qui certifie les données. Donc, du coup, c'est qui l'oracle à ce moment-là, pour toi, je te laisse répondre à la question.

Meriyem : Le médecin.

Daniel Yasri : Exactement un Allergologue ou un médecin. Tu vas voir ton médecin et il va te faire ton petit d'allergie. Et hops, t'es allergique aux acariens, lui, du coup, via sa clé privée, ce qu'il se passe, c'est que toi, tu vas lui donner ce qu'on appelle, différents types d'accès, je te parle d'un monde idyllique. Mais voilà, comment ça marcherait, tu mettrais ton portable en sans contact sur sa borne où il serait marqué, acceptez-vous de donner l'accord d'oracle à Docteur Machin ? Tu dis oui et tu choisis la catégorie. Bon, là, je vais vraiment dans la démarche. Tu n'as pas envie que ton cardiologue parle de tes poumons, ou quoi que ce soit et tu dis "oui, je donne accès pour les allergies". Le médecin avec sa clé privée d'Oracle, parce que c'est une clé de consortium, c'est à dire qu'on garde la clé privée, ce n'est pas public, comme le bitcoin où il y a tout le monde, les patients, les médecins et les pharmaciens. Là, avec sa clé privée, il va apposer sur ton dossier que c'est bien lui, Il certifie cette donnée en tant qu'Oracle, en tant que médecin, que tu es allergique aux acariens et du coup, t'as donné d'un coup, tu gagnes en qualitatif. Je vais avoir le prochain médecin et il prend tes données. Et tu dis que tu es allergique aux acariens, il va dire, ah en effet, c'est bien marqué. Alors imagine, pour les gens qui ont des maladies chroniques, il n'a pas à se taper tout le dossier, il voit exactement ce qui est vrai, etc. Du coup, tu vas chez le pharmacien. Il t'a fait une ordonnance qu'il a avec sa clé oracle qu'il a mis sur ton téléphone fin sur ton dossier parce que tu sais que la blockchain ce n'est pas sur téléphone. C'est quelque chose de décentralisé. Tu vas à la pharmacie, elle voit, Ah ben oui, en effet, ça a été fait par tel Oracle donc un médecin. Et avec son pouvoir de

pharmacienne, elle te délivre les médicaments et donc, du coup, dans ton dossier patient apparaît que si jamais tu vas voir un autre médecin, tu te dis écoutez-moi, je prends tel médicament et fait ah bon ? J'aimerais bien voire quand même parce que c'est important, et tu lui montres. Ce n'est pas toi qui as avancé ces médicaments, c'est la pharmacienne avec le double oracle de la prescription du médecin et en tant que pharmacienne qui te délivre, refait bien sa clé privée, re certifie ta donnée, en disant oui, madame Meriyem elle a bien pris ses médicaments. C'est comme ça que ça marcherait, en fait. Et en fait, à chaque fois que tu rentrerais une donnée sur la blockchain, ça rajouterait à ton dossier et en fait, tout simplement y aurait des oracles, c'est le mieux. C'est d'ailleurs comme ça que ça devrait marcher et ça ne peut pas fonctionner autrement. Une blockchain de santé, a besoin d'oracle. Elle a besoin de certifier des données. Si t'as des données pourries, ça ne sert à rien d'être sur Blockchain. Si c'est pour que tout le monde mette ce qu'il veut, qu'il a telle allergie, tel truc, tel machin, ce n'est pas intéressant.

Meriyem Yasri : Le médecin, ça lui demande un travail d'aller confirmer cette donnée ?

Daniel : Si les outils sont là, ça ne lui demande pas de travail. Tu plaquerais ton téléphone contre sa borne et lui ferait "entrer". Nous, les médecins, on a une carte CPS et c'est ce qu'on utilise pour faire des ordonnances ou rembourser les soins, etc. Et c'est exactement pareil. Là, ça serait une carte entre guillemets ou sa clé privée qui ferait exactement la même chose qui validerait le fait qu'il a activé la donnée. Ça ne demande pas de travail. Elle est juste branchée dans la machine la carte et quand je fais une ordonnance, ça interroge la carte et ça a l'ordonnance en 2 secondes. Ce n'est pas du boulot en plus, au contraire, c'est du boulot en moins. Parce que combien de fois nous, les médecins, je vais voir un patient quand il arrive vers 60 ans et je fais alors que, c'est quoi vos antécédents et qu'il en a aucune idée, le pauvre, qu'il sait même pas quel traitement il prend, Et qu'est-ce que ça nous faciliterait la vie que je dise écoutez Donnez-moi votre carte machin ou blockchains, ou je ne sais pas comment on l'appellerait mais, on le prend et puis hop ce serait fini quoi.

Meriyem : Les oracles ça existent déjà ?

Daniel Yasri : Ça existe, ça existe. Mais personne n'a encore percé dans la blockchain médicale. Il y a beaucoup de blockchain médicale qui essaie, Il y en a beaucoup mais c'est juste que personne n'arrive à s'imposer sur le marché parce que les gens sont frileux, parce qu'il y a des limites à la technologie, et ça, c'est ce qu'on verra plus tard parce que je sais que c'est une de tes questions de limites aussi. Autre use case de santé, c'est tout ce qui est traçabilité, réalisation des médicaments, tu dois savoir que c'est un gros problème. Vraiment. Si tu travailles sur ça dans ton mémoire, sache que la contrefaçon des médicaments, c'est un souci majoritaire, qui est majoritairement en Afrique. Plus de deux tiers des médicaments qui sont faux. Cinquante pour cent des médicaments sur Internet, ça engendre un million de décès par an les faux médicaments. Et c'est plus de 10 milliards de manque à gagner. Du coup, grâce à Blockchain, on pourrait facilement réaliser les boîtes de médicaments, via ce que je t'ai expliqué. On aurait juste à vérifier en se disant ah c'est bien le bon hash. J'ai écrit tout un article. Pour moi ce qui est aussi super important ce sont les essais cliniques aussi. Je t'invite à voir l'article qu'on a écrit avec Kori. C'est vraiment ultra important. L'essai clinique ça rentre dans la blockchain parce que on collecte des données de recherche, donc collecte des données dit blockchain. Comme on vient de le dire. Pourquoi ? Parce qu'on veut certifier la donnée. Parce qu'on veut être sûr

qu'elle soit timeStamper, on veut être sûr que ce soit la bonne donnée. Tu ne peux pas te permettre dans un essai clinique, de dire ce n'est pas la bonne, je ne suis pas sûr que ce soit le bon patient, je ne suis pas sûr que j'ai donné tel médicament. Ça respecte le protocole, du coup, tu peux être sûr d'une traçabilité et ça permet d'inclure plus facilement des nouveaux patients puisqu'ils pourraient tout simplement, grâce à leur dossier médical, leur clé, rentrer dans l'essai. Tout le potentiel du Big Data, si tout le monde avait tout simplement à travers son téléphone, la possibilité de participer à un essai clinique parce qu'il serait interrogé en mode : ah on cherche des diabétiques, hop tu rentrerais dans l'essai. On pourrait également l'appliquer aux maladies rares, tu pourrais faire énormément de choses. Par après, on peut aller encore plus loin, il y a l'assurance maladie avec tout ce qui émet des meilleurs remboursements contre la fraude. J'en avais déjà parlé, tu as toute la santé publique pour la gestion des épidémies. Ça serait vraiment génial. Je ne pensais jamais à devoir dire ça un jour, mais s'il y avait une pandémie mondiale, tout ce qui est transfusion et dons d'organes, tout ce qui est traçabilité des transfusions et des dons d'organes, ce serait tellement important de pouvoir tracer ça de manière ultra carrée.

Meriyem : Mais j'ai une question, on parle surtout, du coup, que la blockchain publique, ce n'est pas spécialement ce qu'on utiliserait.

Daniel Yasri : C'est une blockchain privé/public. Public dans le sens que certain pourrait consulter ton dossier. Il faudra être oracle pour le consulter, tu n'as pas envie que tout le monde consulte ton dossier médical. C'est semi-public, semi-privé. On appelle ça vraiment une blockchain de consortiums. Si vraiment tu cherches le terme, c'est vraiment ça. C'est entre privé et public et c'est vraiment ce qui s'applique dans le domaine de la santé. Pour moi, le mieux. Mais la blockchain, c'est vraiment très compliqué. Et c'est compliqué à faire aussi. C'est compliquer à coder, à appliquer, à faire. Moi tout mon travail de consultant consiste à mettre en lien ce que veulent les professionnels de santé avec les développeurs qui souvent ne comprennent rien l'un à l'autre. Donc vraiment, le problème c'est la complexité et surtout le risque, qui me fait peur c'est de tomber dans la diversification des blockchains. Et qui risque de faire une désunification, c'est-à-dire que par exemple, ce qu'il va se passer un jour sans doute, tu sais que l'Estonie a passé tous ces citoyens sur la blockchain. Le problème c'est que si demain la Belgique fait sa blockchain, ça ne va pas être la même. Et si on n'a pas cette interopérabilité, on va avoir les mêmes problèmes sur l'exécution des contrats, des smart contracts, sur tout, ça va être la même merde. Il y a un problème de standard en blockchain, chacun fait ce qu'il veut. Consommation énergétique également, qui est réglé avec le proof-of-stake, proof-of-authority, etc. La taille du réseau blockchain. Il faut quand même plusieurs nœuds pour arriver à accomplir cette vision de décentralisation. Tu ne peux pas dire j'ai 3 serveurs je fais une blockchain. Mais on retombe dans les mêmes problèmes, si tu as 3 serveurs, on retombe sur les mêmes problèmes. La taille du réseau c'est vraiment quelque chose qui peut freiner la blockchain. Il faut beaucoup de nœuds. Pour éviter aussi les 51% attacks. La vitesse et efficacité, la blockchain ça peut être très lent comme tu peux le savoir. Le bitcoin c'est un bloc toute les 10min. C'est trop long pour le domaine de la santé. L'Ethereum c'est un bloc toute les 20 sec. Mais il y a ce problème actuellement de frais de transactions qui sont au plafond avec la congestion du réseau car tout le monde utilise Ethereum pour plein de raison. Autre vulnérabilité c'est la vitesse et son efficacité. Il faut que ça aille vite. Gestion de l'erreur. Il faut faire attention. Normalement il n'y a pas d'erreur en blockchain mais ça permet d'éviter ça. Mais il ne faudrait pas qu'il y ait une erreur dans un bloc. Il faudrait

s'assurer qu'il n'y ait pas d'erreur. Ce n'est pas arrivé, mais si ça arrive, ce serait dommage. Il y a aussi selon moi, le défi légal. Est-ce qu'on peut mettre des données patients sur blockchain. J'ai écrit aussi tout un article dessus, tu verras, la GDPR, les données patients, les données des gens, est-ce qu'on a le droit dès les mettre sur la blockchain ? La blockchain c'est immuable, du coup comment les gens peuvent retirer leurs informations. Tu as le droit à l'oubli. Mais en fait, ça ce n'est pas impossible. Il suffirait juste d'ajouter une transaction par-dessus l'autre. C'est comme si tu ne veux pas qu'on voit que tu as 50 bitcoins sur cette adresse, tu as juste à le bouger sur une autre adresse. On pourrait faire une transaction pour virer tout, ce serait pareil. Mais voilà, il y a beaucoup de défi légal pour la blockchain. Standard et interopérabilité.

Meriyem : Mais si maintenant je suis un patient et qu'un jour il y avait l'information comme quoi il y avait une certaine maladie, et qu'après je me dis que je ne veux plus que les gens sachent, je ne peux pas juste transférer entre guillemet l'information.

Daniel Yasri : Non, tu n'as pas besoin de transférer, mais tu peux faire une transaction qui va écrire au même endroit. Tu vas juste rehasher le hash. Avec ta clé privée, tu vas signer un message. Le souci c'est que ça n'aura pas disparu dans les blocs précédents. Mais les blocs d'avant, personne ne les regarde et ils seront accessibles qu'au médecin. Mais on peut aussi très bien s'imaginer dans une blockchain de consortium, tu fais ce que tu veux dans ce type de blockchain, ben que le bloc N-1 il n'est pas accessible. Ce serait très facile à faire et ce serait une des solutions. Dans les blocs suivants on ne voit plus rien. Et les blocs avant ne sont pas intéressants. Tu es intéressée que par le bloc présent. Il y a 3 trucs dans le GDPR, le droit à l'oubli, le droit de savoir où est son information et le consentement.

Le coût, c'est aussi un problème. Ça coûte cher de développer une blockchain. Il faut des ressources technologiques et financières qui ne sont pas comme les solutions traditionnelles. Mais après, quand il y aura des acteurs comme Microsoft, Amazon, IBM qui vont s'y mettre, et que ça va devenir accessible, il n'y aura pas de soucis.

Meriyem : Et on a déjà parlé de certains avantages, mais il y en aurait d'autres auxquels vous pensez ?

Daniel Yasri : Avantages c'est moins de paperasse, moins de soucis de stockage. Tu te rends compte que le SHA 256, tu peux hasher un livre et que ça fera que 64 caractères. Tu peux mettre tous les livres dans 64 caractères. Et ces 64 caractères seront par exemple égal à Harry Potter. Le gain de place, il est incroyable.

Meriyem : Et si après on dit que vous avez hasher ce livre et que vous voulez me donner accès à ce livre. Ça se passerait comment ?

Daniel : Alors là, en effet ça va plus loin que la blockchain. Tu ne peux pas mettre le livre sur la blockchain. Tu as tout à fait raison. Dans ce cas-là, on y accrocherait des métadonnées. C'est quelques choses que tu mettrais en plus, par exemple ce serait tel hash correspond à tel PDF et l'adresse du PDF. Mais au lieu justement que tout le monde doit avoir le PDF, en fait dès que tu as le hash, tu as la même Métadonnée et du coup il est à un seul endroit. Alors actuellement, tu sais que les livres il y en a des copies partout à travers le monde. Pareil quand tu vas chez le médecin, à chaque fois, il y a un nouveau dossier médical qui est créé et ça reprend de la place. Alors que, ce serait égal à une localisation

pour une métadonnée. Une métadonnée, une localisation, pour une donnée. Donc pour te partager un livre, il faudrait que je te donne l'accès comme pour une transaction et en fait la blockchain va t'envoyer la métadonnée et ce qu'elle fait surtout, c'est que le PDF, c'est le bon hash, que je n'ai pas modifié le truc et que t'as le bon livre.

Meriyem : Quand j'ai fait des interviews, il y a certaines personnes qui insistaient que la blockchain n'était pas une database.

Daniel : Ils ont raison, mais c'est faux de dire que ce n'est pas une database, ça peut être une base de données mais ce n'est pas un endroit de stockage de donnée. Dans les autres qualités, ça permettrait d'avoir une plus grande qualité de soins. Vu que si tu as des meilleures informations, qui sont à jour et qui sont compréhensible, ben tu as une meilleure qualité de soins tout simplement. Meilleure efficacité et productivité également. Et pour moi, ça met le patient au centre, comme c'est toi qui as la clé privée, c'est toi qui as ton dossier en main donc tu deviens beaucoup plus acteur de ta santé. Les patients ne savent pas ce qu'ils ont eu, pourquoi ils l'ont eu. C'est vraiment compliqué car ils ne sont pas du tout au centre. Il n'y a pas d'empowerment. Ils font confiance à l'hôpital. S'ils vont au même hôpital depuis 10ans, ils peuvent avoir un bon dossier. La personne déménage, c'est foutu. Il faudrait vraiment des electronic health record.

Meriyem Yasri : Par rapport à l'interopérabilité, ça peut être un avantage et un inconvénient ? Car ça peut être un avantage entre pays dû au manque de standard, mais un avantage entre institutions ?

Daniel : Exactement. Il y a 3 types d'interopérabilité, il y a la sémantique, structurelle et fonctionnelle. C'est très important, surtout en médecine. Tu devrais aller regarder. La sémantique ça permet l'interprétation des données échangées, sur la syntaxe mais aussi sur ce qu'elles veulent dire. Par exemple, la structure se serait patient A, telle maladie : etc. sémantique c'est à dire qu'il comprendrait qu'il y a plusieurs champs. Ça c'est la syntaxe, la structure mais que tel champs, à quoi il est égal et donc que tel champs, maladie ça veut dire maladie. Interopérabilité structurelle c'est quand un format de la donnée clinique est changé, est garanti que les données reçues sont préservées et se rapporte au champ de donnée. Il voit qu'il y a différente tram dans la structure, par exemple qu'un Patient A Meriyem, ce n'est pas égal à diabète, etc. Et fondamental c'est ce qui permet d'échanger des données de santé, sans hésiter que ce qu'elle reçoit, elle est capable d'interpréter les données. Ça c'est le plus bas niveau d'interopérabilité. Le but c'est d'arriver à des niveaux toujours plus élevés dans l'interopérabilité. Donc du coup, partir de la fondamental pour arriver à la sémantique.

Meriyem : Ma prochaine question est comment une transaction est signée ?

Daniel Yasri : C'est signé par la clé privée qui va du coup va ajouter un hash à la transaction et qui va montrer en effet que ça appartient bien à telle personne. Elle est signée par l'expéditeur, après elle va être entre guillemet signée par le nœud qui va valider la transaction.

Meriyem : Comment la blockchain peut-elle aider à augmenter les droits que les patients ont par rapport à leurs propres données ?

Daniel : Alors là c'est toute la discussion qu'on vient d'avoir. Le fait qu'il peut mettre ses propres dossiers, savoir qui a accès. Par exemple, je suis psychiatre, ton patient, il est mal vu, les gens disent qu'il est fou, etc. C'est dommage, c'est une maladie. Du coup si tu veux aller chez un médecin avec tout ce qu'on vient de dire, tu peux juste choisir en cochant, je souhaite donner accès qu'à cette partie à cet oracle et comme ça il a accès à tout, sauf aux données psychiatriques. Ce qui est déjà le cas dans notre système. Ça permet vraiment de mettre le patient au centre. Au centre de ses données. Tu vas sur ton téléphone et tu sais enfin ce que tu as. Tu t'impliques. Egalement, si on avait du big data, ça permettrait que le patient puisse monétiser ses données anonymement via la blockchain. Ce serait facile via la tokenization s'il reçoit une notification avec : nous cherchons des patients diabétiques, tu dis ah ben bien sur ça ne me dérange pas d'échanger mes données et puis par exemple tu reçois en échanges un cryptomonaie par exemple. Alors que maintenant, les dossiers patients sont vendus sans leur consentement. Il faut savoir aussi que les données médicales coutent plus cher en termes de marché noir que les données bancaires. Pourquoi ? Aux Etats-Unis, ils ont un système d'assurance ou si tu as certaines conditions médicales comme le diabète par exemple, tu as droit à certaine chose. Et donc c'est ce qui est le plus pirater. Plus d'une assurance sur 3 est frauduleuse aux USA. Ça leur fait près de 68 milliards, c'est une grosse perte. Ça mettrait également le patient au centre. On ne doit pas lui poser 36 000 000 questions, vous êtes sûr, ce n'est pas pour avoir de l'argent ? Ben non regardez, 3 oracles ont signé en disant que j'étais diabétique.

Meriyem : et en parlant du fait que c'est le patient qui a ses datas et que ça peut être monétiser, est ce que ça pourrait retirer le pouvoir des grosses entreprises comme les GAFA ? Et donc arrêter qu'ils aient toutes les données car le patient choisit s'il est d'accord de partager ses informations.

Daniel Yasri : C'est déjà le cas ça, vous avez le GDPR en Belgique aussi. On te demande d'accepter les données. Puis les GAFA n'ont pas trop de poids au niveau des santés patients. Ils ont beaucoup de mal, les boîtes d'avoir les données patients, c'est très compliqué. Je pense au contraire que ça leur faciliterait la tâche si on avait tout le monde sur une blockchain. Parce que ça leur permettrait de rémunérer les patients et les patients seront plus à même de transférer leur données et donc pour une fois, ça va plus dans leurs sens.. Je pense que ce serait vraiment une interconnexion et donc un gagnant-gagnant pour les patients et pour ce genre d'entreprises. Et au vu du cadre légal au moins dans nos pays, ils auront du mal à avoir accès à nos dossiers patients. Et ça justement, si on arrive à ce système, on arrivera à un moment où les patients voudront bien les donner. Et je pense que ce sera une bonne chose. Donner des données anonymisées bien évidemment, ça serait génial pour tout le monde.

Meriyem : Dernière question par rapport à la blockchain, comment la privacy est respectée ? Et grâce à quel moyen ?

Daniel Yasri : Il y a plusieurs réponses. Ça dépend du type de blockchain, si c'est public, personne ne connaît ton adresse, personne ne connaît la transaction, normalement c'est qu'entre nous deux. Tu connais mon adresse, je connais ton adresse, que nous deux pouvons vérifier. Soit c'est une blockchain privée. Dans ce cas-là, si tu n'es pas oracle, tu ne peux pas voir les données publiques des gens, si c'est une blockchain de consortium. Une blockchain privée c'est encore plus restrictif, si tu ne fais pas partie, tu ne peux pas avoir accès à la blockchain. C'est comme ça qu'on respecte l'anonymat, c'est en mettant

des master key moi je dirais. C'est-à-dire que tu as une clé privée pour chaque utilisateur, il y a des gens qui ont plus de pouvoir sur leur clé et bien sûr ces clés devraient être auditées. Et donc on aurait accès au dossier patient, parce qu'on est médecin, parce qu'on a fait des études et qu'on a fait un serment etc. Et là c'est pareil, on devra distribuer les clés aux bonnes personnes les master key, les clé oracle. C'est plus sécurisé que maintenant parce qu'il suffit d'avoir le mot de passe du patient pour avoir accès à tous les dossiers des patients. Alors que si c'était une clé privée, ce serait autre chose. Il faudrait une authentification à deux facteurs. Et ça, ça permettrait encore plus de garantir le problème du patient car même de nos jours, un médecin peut avoir accès au dossier patient de n'importe qui même s'il ne l'a pas pris en charge, même si ce n'est pas permis.

Meriyem : D'accord, je pense qu'on peut passer à la partie sur l'intelligence artificielle.

Daniel Yasri : D'accord, allons-y

Meriyem : Comment définiriez-vous l'AI ?

Daniel Yasri : ça dépend laquelle, il y a plusieurs types d'IA, Deep learning, Machine learning, ou tout simplement l'IA sur ses plus simples appareils. Avec le fait par exemple qu'on ouvre une porte, qu'elle nous détecte par un laser, c'est une AI au final. Actuellement, le but c'est quand même un ordinateur qui va répondre à un problème et plus rapidement que l'humain.

Meriyem : Dans mon mémoire, je parle plus du ML car selon ma lecture c'est ce qui est le plus utilisé au sein du domaine de la santé.

Daniel Yasri : Exactement, c'est plus le ML qui est utilisé.

Meriyem : A quelle challenges, difficultés, l'AI fait elle actuellement face ?

Daniel Yasri : Déjà, les limites de l'AI, c'est que tu peux faire seulement ce qu'on programme. C'est limiter à des problèmes complexes qui nous semble limité en termes de rapidité et d'enjeux mais qui sont en fait des problèmes simples. L'AI ne peut pas faire que des choses simple. Elle ne peut pas faire quelque chose qui est humain, elle ne peut pas conscientiser les choses. Elle ne peut pas faire un choix moral, elle ne peut pas changer de plan au-delà de ce qu'on lui a déjà donné. Si elle rencontre une situation pour laquelle elle n'a pas été préparée, l'IA n'a aucune utilité. Et ça, parmi les grosses limites de l'IA, après tu as beaucoup de limites, comme par exemple que le fait que l'IA demande une puissance de calcul qui est quand même énorme, donc au niveau des couts, de qui peut le faire, comment le faire, c'est difficile.

On ne peut répliquer artificiellement ce qu'on ne peut modéliser. Par exemple, on ne peut pas recréer un humain depuis l'échelle microscopique jusqu'au plus grand niveau de complexité donc on ne pourrait pas recréer les propriétés de notre cerveau, il faudrait partir d'une représentation assez formelle qui serait le fonctionnement à un niveau plus large, par exemple celui du réseau de neurones et ainsi de suite et ce sont des choses qui prennent beaucoup de temps. Et sans la présence d'un humain, c'est qu'une machine.

Au niveau éthique, le fait que les données puissent être traitées par quelqu'un qui n'est pas humain, ça peut poser problème. Ça amène à l'autonomisation, ça peut aussi inquiéter

par exemple les radiologues, on a vu qu'ils pouvaient mieux lire les images que les radiologues, donc ça peut avoir un souci au niveau de l'emploi pour certaine personne. Également, l'absence de prise d'initiative, c'est une grande limite de l'IA. Elles ne peuvent pas faire des choix défiant leur fonctionnalité de base. En plus, leur fonction peut être contraire aux règles sociales et morales. Par exemple, ils n'ont pas laissé décider un AI de qui va être soigné ou non en cas de crise du covid par exemple. On ne peut pas laisser une machine choisir si la peine de mort c'est bien ou mal, quelle personne privilégiée pendant un tremblement de terre. Le choix des machines repose que sur l'optimisation et ne prends pas en compte la complexité des situations. Mais vu comme ça déjà, ce n'est pas une limite que la blockchain peut résoudre.

Le pooling de data pourrait aussi être un problème. C'est quelque chose dont on a déjà parlé, l'AI, pour fonctionner au mieux, elle a besoin de données qualitative. Et donc ces données qualitatives peuvent être quelque chose très difficile à obtenir et à certifier.

Meriyem : Je pense que par rapport à la qualité des datas comme vous venez d'en parler, on pourrait regarder, les problèmes que j'ai découvert pendant ma recherche et les questions lié à la Blockchain pouvant potentiellement aider l'AI ?

Daniel Yasri : D'accord

Meriyem : Donc, par rapport au data management, comment le Blockchain, pourrait, selon vous, faciliter l'accessibilité aux data qui sont utilisés pour l'AI et si oui comment ?

Daniel Yasri: Je pense que la blockchain peut absolument aider l'IA en termes de big data. La triangulaire big data – blockchain – AI c'est vraiment ce qui fait que la blockchain et l'AI peuvent travailler ensemble et sont une technologie d'avenir. Ça va te permettre de certifier tes données, d'avoir un registre énorme qui peut être trustworthy, ou tu n'as pas de question de confiance à te poser car tout est tracé, signé, tout est oraclé comme on avait parlé. Si tu as des données qualitatives, tu fais du machine learning de plus haut niveau et beaucoup plus rapidement. Deuxièmement, la blockchain permet aussi, grâce à des métadonnées de facilement agencer, l'AI sait donc facilement ou chercher. Si j'ai envie de faire une recherche d'AI sur tous les gens qui ont mis leur dossier médical sur la blockchain, et si on tape diabète, la blockchain peut agencer facilement, via des hash comme on avait vu, rechercher sur la blockchain et chercher qui a le diabète et facilement distribuer à l'AI toutes les données qu'elle a besoin. Et ça c'est quelque chose qui permettrait de mettre en place des perspectives énormes. Le big data pour moi, c'est l'essence du ML. Et le ML, c'est la technologie qui permet d'extraire complètement le potentiel du big data. Le big data en médecine, ça peut permettre par exemple un jour si tout le monde mettait ses données de santé et on mettait le ML dessus pour faire des prédictions, pour faire des associations que nous en tant qu'humain on n'a pas vu, ah ben en fait le diabète, je dis n'importe quoi hein, mais ce sont plus les personnes qui sont nées en Mars par exemple. Le ML va nous permettre de spot des choses qui sont impossibles pour un humain ou qu'il faudrait passer énormément de temps à éplucher 1 million de données patients, qu'on ne peut pas faire humainement. Et là tu vas arriver par exemple à traiter des maladies rares. Parce que tu vas regrouper tous ces gens avec des maladies rares parce que tu vas par exemple, prendre tous les gens qui ont cette maladie rare, on leur séquence le génome et le ML fait en fait : c'est ça qui ne va pas, etc. C'est là que c'est intéressant.

Meriyem : Et pour ça, il faudrait que la blockchain soit répandue assez globalement ?

Daniel Yasri : Il faut que la blockchain perce, que les gens se mettent sur la blockchain, ou qu'ils acceptent entre guillemet d'envoyer leurs données et stocker leurs données sur la blockchain en effet. Du coup, le big data c'est vraiment la clé pour exploiter la médecine et la blockchain.

Meriyem : Donc ça peut faciliter l'accessibilité aux data mais ça doit être plus répandue ?

Daniel Yasri : Exactement. Après, globalement je ne sais pas. Si tu le fais juste à l'échelle d'une ville, ou d'un hôpital, déjà tu vas avoir plein de choses avec du machine learning. Parce que, les avantages de la blockchain, tu augmentes la qualité et l'intégrité de tes données, et la provenance, la sécurité, la transparence. Comme use case, on a les health record, intégrés dans un système de santé, des médicaments tracés, des essais cliniques facilement traçables et mis sur la blockchain. Et une fois que tout ça, tu l'extrais et en fait du big data, tu peux facilement l'envoyer dans l'IA et dans la blockchain. Tu n'as pas besoin à mon sens d'avoir forcément ça mondialement ou que ce soit populaire. Si juste un centre avec 1000 patients le faisait, ce serait déjà bien. Il faut juste par contre qu'ils se mettent dans la blockchain, qu'ils acceptent de faire le pas ou d'investir dans des gens qui développent la blockchain. Je fais souvent l'interface entre ces deux personnes, entre des professionnels de santé qui demandent quelque chose et qui ont besoin de trucs pour eux qui sont évident et les développeurs de blockchain qui n'ont aucune connaissance médicale ou pharmaceutique et qui du coup doivent coder des choses qu'ils ne connaissent pas. Et c'est là où l'interface est un peu compliquée. Mais je pense en effet que ça doit être repandé mais il faut vraiment que les gens se lance là-dedans, que ça marche.

Meriyem : Et pour ça, c'est important que le patient soit maître de ses datas ?

Daniel Yasri : Non, après le patient, en tout cas en Europe, il est toujours maître de ses données. Tu peux demander ton dossier et tu as ton dossier. Tu vas demander à ce qu'il soit supprimé, ils le suppriment. Donc dans tous les cas, c'est la même chose. Après, de là à ce que le patient soit en contrôle total comme on a pu l'imaginer ensemble tantôt, par exemple, il suffirait juste qu'il signe. J'ai théorisé un consentement via la blockchain car le consentement actuel c'est un gros problème dans les essais cliniques à travers le monde, ça se fait sur papier. Et en fait, si c'était sur blockchain, j'ai une présentation sur tablette où tu mets ton empreinte digitale, ton numéro de sécurité social ou quelque chose comme ça par exemple. Après, il faut juste que le patient consente. Tu sais, la blockchain, ça fait peur aux gens. Tu n'as pas besoin de parler de la blockchain. Tu parles d'application de santé, et dire, accepteriez-vous d'utiliser une application de santé et que via l'AI, on peut trouver un remède ou des associations, tu n'as pas besoin de dire le mot blockchain tu vois. Et le patient n'a pas besoin d'être tout le temps sur ses données. Il peut juste dire oui j'accepte, comme on fait maintenant en fait. Actuellement, il n'y a aucun patient qui me demande tous ses résultats, dès que je fais un truc, ses résultats de prise de sang, ou qui me demande à quoi j'ai utilisé ses données, à qui je les ai partagées, etc. C'est normal, ils me font confiance, ils m'ont donné la première fois leur accord et a dit : je veux bien que vous travaillez avec mes données, avec mon dossier médical, etc. Là c'est pareil. C'est un truc qu'il faut que tu fasses ressortir dans ton mémoire, c'est que la première erreur qu'on a fait, en rentrant dans ce milieu-là c'est qu'on a beaucoup parlé blockchain et que ça a fait peur aux gens alors que c'est juste une technologie. C'est comme dire internet, je n'ai pas

besoin de te dire internet, si je te dis, viens on fait un call, je ne vais pas te dire viens on fait un call via internet. Pour moi un jour, la blockchain ce sera pareil. Tu sais que tes données sont sur blockchain, c'est évident pour toi, mais il faut qu'on arrive à ce niveau-là. Et pour arriver à ça, on doit faire en sorte de faire disparaître la blockchain en tant que mot, qu'entité, que les gens ne comprennent pas. 99% des gens ne savent pas comment fonctionne internet. Mais tout le monde sait comment avoir internet, comment l'accéder, pourquoi c'est utile. La blockchain c'est pareil. Un jour les gens vont savoir que c'est un registre, transparent, c'est sécurisé, c'est tout. C'est le challenge.

Meriyem : Si maintenant, la blockchain est utilisée au niveau d'une institution, ça peut déjà aider à créer une AI, ou on peut déjà avoir plus de data pour en créer une, mais si maintenant, on veut limiter la discrimination que fait l'AI, ça peut aider à diminuer cela ?

Daniel Yasri : Oui en effet la discrimination, c'est un problème de l'IA mais la blockchain ça te permet de certifier des données, il n'y a pas tout le monde qui donne son point de vue comme ça. Ça veut dire que si la personne elle dit les bonnes choses, au moins c'est étiqueté. Sur twitter, tout le monde dit ce qu'il veut et si je dis que je suis professeur, personne ne peut vérifier que je suis bien professeur.

Meriyem : Et alors, comment la blockchain pourrait diminuer la discrimination ? Si on a plus de data venant des populations des pays en voie de développement par exemple, on peut mieux créer nos modèles ?

Daniel Yasri : C'est plus une erreur matérielle ou humaine. C'est une erreur de programmation. C'est que les personnes n'ont pas codé les contrastes, etc. En effet, on peut dire que c'est dû à un manque de données mais également par un manque d'intelligence du côté humain. En 2009, les caméras HP n'arrivaient pas à reconnaître les gens noirs car on n'avait pas assez de contraste. En 2015, le Google photo a mis certaines personnes noires en gorille. Pour moi c'est parce qu'on a lancé l'AI sans lui donner les moyens. On a fait ça pour un certain sous-groupe de personne. Après est-ce que la blockchain elle a vocation à répondre à ça, je ne pense pas. Ce sont les gens qui codent cela à l'avance qui doivent savoir qu'il y a des gens métisses, chinois, etc à la base. Il faut que ce soit déterminé avant. Ils ont codé le modèle sur certaines personnes et après, ils ont essayé sur des personnes différentes et là ça ne fonctionne pas, ça peut également être un problème, c'est une erreur de codage de nouveau. Donc, est-ce que la discrimination peut être aidée par la blockchain, non. Est-ce que ça a un rapport avec la transparence des données, non, le registre non, la circulation, la provenance non, l'intégrité, non, donc non. Fais ta checklist et là tu verras les vrais use case.

Meriyem : Et concernant les potentiels biais ?

Daniel Yasri : L'IA, une fois de plus à des biais qu'on lui donne, une fois de plus ce n'est pas quelque chose que la blockchain peut résoudre. La blockchain, ça a été une mode dans les années 2016, 2017, 2018 ou on faisait que parler de ça tout le temps. On voulait mettre la blockchain à toutes les sauces. Alors que, moi qui suis dans la blockchain depuis 2011, et qui a essayé plein de trucs et conseillé des entreprises, il y en a qui voulait utiliser de la blockchain pour tous et partout. La blockchain, ça sert à : transparence, sécurité et intégrité des données. Ce sont les 3 choses que ça permet de résoudre, ça ne va pas faire plus que ça. Il y a d'autre système qui font les choses mieux que la blockchain. Tu as des

données qui arrivent, tu veux qu'elles soient sécurisées, transparentes, timestamp, de qualité, savoir d'où elles viennent, assurer leur provenance, tout ça, la blockchain répond. Donc vraiment, les interactions IA-Blockchain, c'est je plug du data qui est qualitatif. C'est énorme en fait. Les gens ne s'en rendent pas compte. Le ML c'est dépendant que de ce que tu lui donnes. Donc si tu peux t'assurer des données qualitatives avec des labels par exemple, comme si tu dis : oui, regarder, je vous assure, ça vient de tel truc, c'est tel hash, ça vient de là etc. Et mon robot, il est entraîné qu'avec des datas de qualités. Je peux vous dire, je vous assure ce sont tous des patients diabétiques de type 2 et je vous l'assure. Personne ne peut faire ça aujourd'hui. Personne ne peut vérifier que ce soit la vérité. Je pourrais avoir écrit le dossier médical comme ça et si ce n'est pas signé par la clé privée d'un patient, tout en restant anonyme par exemple, tu peux très bien vérifier que ça appartient à de vraies personnes et que ce sont de vraies données.

Meriyem : D'accord. Et on en a déjà parlé, mais concernant le data management, comment la traçabilité et la transparence des données utilisé peut être atteinte ?

Daniel Yasri : Exactement, on en a largement parlé. Les deux mots que tu viens d'employer, c'est tout notre discussion. Il faut vraiment que tu parles du hash, des signatures, des clés privées, de clé publique et que vraiment, l'intégrité et la provenance des données, la blockchain excelle dans ça, c'est fait pour ça. Donc ça vient vraiment se compléter avec l'AI.

Meriyem : Est-ce que la blockchain peut également aider à la traçabilité de comment une décision a été prise ?

Daniel Yasri : C'est possible, si tu prévois que ce soit possible. Si par exemple, on a une AI qui fait du ML et qui choisit : lui il faut injecter, lui il ne faut pas injecter, etc. Oui ou non quoi, un truc binaire. Et que en fait, c'est en fonction de certain critère que tu as prévu, quand tu as codé cette IA, ben de pouvoir voir quel chemin il a pris. Il a des branches et il prend la branche de droite, celle de gauche, etc. Et ça fait un arbre de décision jusqu'à arriver à la décision. Si par exemple, tu décides que ce qui serait intéressant de mettre chaque arbre, que l'IA prend la décision et l'enregistre sur la blockchain son arbre décisionnel, alors oui. Dans ce cas-là, ça répond à ta problématique. Tu vas dire, ok il y a eu un problème, je veux savoir ce qu'il s'est passé, parce que tu vas pouvoir dire, il s'est passé un problème. On va te dire, moi je pense que c'est l'IA, tu vas dire non je veux être sûr, tu peux me prouver, me montrer que c'est à telle heure qu'il a pris sa décision, et que c'est arrivé ? Tu vas sur la blockchain, tel hash, timestamped, ok ça correspond exactement à la décision et en plus, est-ce que tu peux me sortir l'arbre décisionnel ? Ben oui parce que on a enregistré la décision sur la blockchain. Donc oui, une fois de plus, elle a été signée par notre IA à telle heure, c'est bien la décision qui a été prise à cette heure-là, donc on peut le vérifier. Ça peut aider, mais il faut que l'IA, et les gens qui codent l'IA, la code de manière à ce qu'elle enregistre sa décision et qu'au moment de la faire, elle aussi elle la valide via la blockchain. Et qu'elle met son arbre décisionnel sur la blockchain. Mais le oui, ça pourrait être utile en effet, parce que tu veux tracer quelque chose, son intégrité et sa provenance de manière certaine. Donc tu veux être sûre que ce soit bien maintenant, que ce ne soit pas le patient d'avant et tu peux le prouver.

Donc tu as compris pourquoi ça pourrait aider et comment on ferait. C'est vraiment de la signature une fois de plus, du moment, de l'endroit, de l'AI, de la personne concernée, où

un arbre décisionnel aboutit à un hash et où tu peux vérifier que c'est bien le moment et l'endroit où il a pris la décision et comment. Tu pourrais le faire sans la blockchain, mais grâce à la blockchain, tu pourrais le certifier d'autant plus.

Meriyem : Du coup, au niveau du trust improvement, est-ce-que ça peut aider ?

Daniel Yasri : Bien sûr, ça diminue l'erreur. Que quelque chose ait mal été copié. Tu es sûr qu'avec la blockchain c'était comme ça. Il n'y a pas d'erreur sur le fichier, il ne manque pas d'information, d'information perdue, sinon tu n'aurais pas le même hash, etc. Et les datas, sont plus safe, de qualité, intègre, etc. Mais les gens n'ont pas confiance en l'IA, parce qu'ils n'ont pas confiance dans une machine. Ils n'auront pas plus confiance si on leur dit que c'est prouver, timestamp. Ils vont te dire je m'en fou de croire une machine, je veux un humain. Il faudra donc un travail d'éducation et montrer que l'IA fait plein de bonnes choses. Ce qui est intéressant ce n'est pas healthcare, mais le pilotage automatique, ils font presque aucun accident comparé aux humains, mais le jour où il y a un accident avec une voiture sans conducteur, les gens vont le pointer du doigt. Mais oui l'IA fera des erreurs car elle n'est pas parfaite et est inventée par l'humain. Derrière la confiance qu'on lui octroie, c'est la confiance qu'on met dans les gens qui ont programmé cette IA, et c'est aussi la non-confiance qu'on met dans les machines qui n'ont pas la conscience qu'on les humains.

Meriyem : Au niveau légal, la blockchain peut-elle aider l'AI ? Si oui, comment ?

Daniel Yasri : Evidemment ! J'ai fait tout un article sur les soucis d'assurance qu'il peut y avoir. La blockchain, justement, si tu as un souci légal de healthcare avec tout ce qui est assurance, pour prouver le dossier médical, qui a opéré qui, quel médicament tu as eu avant tel accident, etc. Plein de use case autour de ça. Dans le cadre légal, on peut vraiment aider grâce à la blockchain, c'est évident. Si tu dois régler un litige et que tu es avocat et que je te dis voilà j'ai des données et elles sont certifiées, tu es sûr que tu peux lui faire confiance pour prendre ta décision, il n'y a pas photo, tu vas prendre tes décisions sur des données certifiées. Ça peut vraiment aider.

Meriyem : Et est-ce-que ça peut également aider avec la traçabilité d'une décision prise par une AI ? Par exemple, retracer les étapes prises par un machine pour arriver à une décision ?

Daniel Yasri : Si c'est toi qui as pris la décision, c'est toujours l'humain. Et il y aura toujours une validation humaine. Si la machine est en total autonomie, ce sera celui qui l'a créé qui sera responsable, si c'est toi qui à décider d'écouter la machine, tu es responsable. Savoir qui c'est, ça ce n'est pas possible. Par contre remonter pour qui a fait quoi, qui a pris telle décision à tel moment, si c'est placé sur blockchain et par AI combinée ou juste sur Blockchain, oui c'est possible. Par contre, au moment de la prise de décision, non. La blockchain ne va pas aider. Tu peux enregistrer la décision oui, et ta décision, si tu as décidé d'écouter l'IA ou pas.

Meriyem : Si on parle des problèmes liés à l'intégration de ces 2 technologies ?

Daniel Yasri : Il y a déjà la limite à l'adoption de la blockchain dont on a parlé avant, le coût, la difficulté, la complexité de la chose. Et après, ça va être encore plus un défi

technologique de lier les deux. Que ce soit au niveau du codage, du cadre légal que ça va impliquer, de la gestion des données, de la gestion de l'erreur, tout ça va être des limites qui vont se poser. Et aussi, les compétences qu'il faudra que les gens aient ou pas. D'ailleurs, si on arrive à des niveaux de simplification assez avancés pour que ce soit utilisable par Monsieur tout le monde ou au moins des gens formés, quel niveau de formation il faudrait y avoir. Ce sont des questions qu'il faut soulever. Ce sont clairement des limites à leur implications. Sur le papier, tout est possible. En réalité, tout est une question de moyen, que ce soit financier, humain ou de connaissances en fait.

Meriyem : Et si on devait dire les 3 grands problèmes qui vont être posés quand on veut implémenter l'AI avec la blockchain ?

Daniel Yasri : Les 3 gros problèmes sont la vitesse de traitement, coût et complexité. Dans la complexité, il y a la complexité scientifique, et théorique. Mais au début, la blockchain et l'IA ou la blockchain tout court, ou l'IA tout court ce sera compliqué. Si tu regardes un blockchain explorer, les gens n'y comprennent rien. Mais peut-être qu'un jour se sera facile. Ça c'est au niveau pratique, après il faudra aussi mettre en pratique, il faudra avoir les connaissances pour mettre en pratique, des humains, des ingénieurs qui arriveront à faire fonctionner les deux en même temps.

Meriyem : Et par rapport à la scalability ? Vu que le ML utilise énormément de data ?

Daniel : Déjà, ils vont te répondre d'office oui. Mais je pense que ce sont des gens qui s'y connaissent mais pas trop. Mais en fait, ce n'est pas vrai, tu codes ce que tu veux dans une blockchain. Si tu veux faire une blockchain ultra rapide, tu crées une blockchain ultra rapide, mais il faut juste que tu l'adaptes à ton use case. Si tu prends des blockchain déjà existantes, bitcoin, Ethereum, etc, oui tu as des problèmes parce que c'est déjà existant et ce n'est pas fait pour la santé. Bitcoin c'est fait pour des transactions, Ethereum, pour des smart contract. Mais ça n'a pas été fait exprès pour la santé ou pour l'AI par exemple. Il y a des blockchains qui ont été développées pour l'AI, comme deepbrain par exemple. Mais il y en a. C'est possible, mais il faut à la base que ta blockchain elle soit conçue pour ça. La scalability elle dépend de ta blockchain et il n'y a pas qu'une blockchain. Et ça c'est important. Si je fais développer ma blockchain sur hyperledger, je n'aurais pas de problème de scalability. Si je veux la faire développer sur autre chose et faire autrement, comme sur yota par exemple, je n'aurais pas de problème de scalability parce que c'est fait pour ça. Il faut juste penser ça à la base. Le problème ce n'est pas est ce que la blockchain est scalable c'est plutôt comment rendre scalable ma blockchain pour répondre à mon use case qui est l'intelligence artificielle.

Meriyem : D'accord, et concernant la sécurité, s'il y a un problème, au niveau de la sécurité de la blockchain, ça peut impacter l'AI ?

Daniel Yasri : Tout à fait, j'espère que tu fasses une blockchain public pour une IA, donc tu n'auras pas de 51%. Tu ne peux pas faire de 51% sur un consortium où sur une privée. Les 51% d'attaque c'est ce que tout le monde va dire et c'est un mot clé que tout le monde va faire semblant de comprendre cela. Par exemple, sur une blockchain privée, ce n'est pas possible. Le 51% d'attaque c'est surtout sur le proof-of-work puisque c'est pour dépasser 51% de la vitesse de hashage. Il faut déjà avoir 51% des assets. Donc il faut avoir 51% des bitcoins. Il y a 10 000 000, ça fait 5 000 000, le bitcoin fait 10 000, ça veut dire

que l'homme est le plus riche du monde. Donc oui ça existe dans le proof-of-work si quelqu'un déploie une puissance de calcul supérieur à 51% de la totalité du réseau. Mais pas sur une blockchain privée, etc.

Meriyem : Et qu'est-ce qu'il en est des pays en voie de développement ? Comment serait l'implémentation là-bas et quels sont les problèmes qui pourraient empêcher leur développement ?

Daniel Yasri : Moi ce que je trouve intéressant, c'est que c'est l'inverse. Nous, on a toujours un problème de legacy systems. Donc nous on doit tout changer à chaque fois et les gens n'aiment pas changer. On a mis des années avant de passer à la fibre optique,.. Le changement, les gens n'aiment pas. Alors que dans les pays émergents, vu que les choses sont à construire, c'est beaucoup plus facile pour eux d'adopter une technologie qui est de dernière sortie. Et là c'est une force pour les pays émergents, j'ai travaillé avec le Maroc qui aime beaucoup la blockchain, l'Estonie également même si ce n'est pas un pays émergent mais qui n'est pas un des pays les plus riches, et qui a su faire la transition du papier à la blockchain rapidement. Et le Nigeria, se met à fond là-dedans. Il y a plein d'exemple et ils le font, et ils le font bien. Parce que justement, ils n'ont pas tout à remplacer et il y a moins de résistance de la population. La population n'a rien de base donc c'est comme si c'était quelque chose de nouveau qui marche. Tu ne dois pas remplacer un truc qu'ils connaissaient. C'est donc une résistance dans les pays du premier monde, qui ne veulent pas bouger. Le fameux « tant que ça marche, on n'y touche pas » alors que c'est beaucoup mieux d'améliorer les choses. Mais par contre, le problème numéro 1, ça va toujours être pareil, ça va être les finances de ses pays-là. Et également les cerveaux. Il peut y avoir des cerveaux locaux, mais ils veulent aller dans des pays où ils sont mieux payer. Donc niveau cout, est ce qu'ils pourront assumer le cout de la blockchain, du développement et humain vu qu'il faut des gens qui s'y connaissent. Mais en termes d'adoption, ils sont bien plus enclins à adopter la blockchain que les pays comme nous.

Meriyem : Et également par rapport à l'infrastructure ?

Daniel Yasri : Oui je suis d'accord, une fois de plus, ils ont tout à bâtir, ça va coûter.

Meriyem : Pour finir, j'utilise le TAM model, donc le technology acceptance model qui analyse le perceived easy of use, usefulness, attitude toward it, behavioral intention to use it, and actual system use. La première question est : est-ce que l'intégration de ces 2 systèmes peut aider à améliorer l'AI et la performance des utilisateurs ?

Daniel Yasri : Oui et non. Si le use case est fit. Si la blockchain sert à son truc. Donc si la blockchain est utilisée pour ce qu'elle est. Si c'est bien utilisé.

Meriyem : Est-ce que ça va être facile à implémenter ?

Daniel Yasri : Non, car ça coûte de l'argent et des connaissances.

Meriyem : L'utilisation de la blockchain pour l'AI est claire et compréhensible.

Daniel Yasri : si on le propose à la population, non. Chacun a son domaine de prédilection. Certain connaissent bien l'AI, certain connaissent bien la blockchain, certains connaissent les 2. Généralement non, mais il y aura forcément un jour où les gens auront la double casquette et dans ce cas-là ça va devenir facile oui.

Meriyem : Et pense tu qu'augmenter l'éducation concernant la blockchain est important avant de savoir l'utiliser pour l'IA ?

Daniel Yasri : La population en général ne va pas savoir qu'ils utilisent cela donc il ne faudra pas les éduquer. Il faut augmenter l'éducation pour les gens qui s'y intéresse oui. Mais pas le reste. La population ciblée, c'est très important oui, pour comprendre et voir les use cases possibles. Il manque de développeur blockchain.

Meriyem : Et est-ce que les bénéfices vont surpasser les couts ?

Daniel Yasri : oui, quand ce sera mainstream.

Meriyem : Quelle est ton impression par rapport au fait d'implémenter les deux ?

Daniel Yasri : on a hâte que ça arrive mais ça va prendre beaucoup de temps. J'ai hâte que la blockchain arrive déjà pour les moyens de paiements etc donc qu'elle débarque pour l'AI, j'ai hâte. Et pour le domaine de la santé, combiné, c'est un rêve. C'est idyllique et utopique.

Meriyem : Et vous irez vers cette technologie ?

Daniel Yasri : absolument, je plongerais carrément.

Meriyem : Et penses-tu que dans le futur, elles aient une grande probabilité de finir ensemble ?

Daniel Yasri : Grande probabilité et potentiel, oui, clairement.

Meriyem : J'ai une dernière question, on disait que la blockchain peut aider à décentraliser le computing power et aider l'IA ?

Daniel Yasri : ah ça c'est très intéressant mais ça existait déjà avant la blockchain. C'est le fait d'utiliser la puissance de plusieurs ordinateurs pour augmenter la capacité de l'IA et de calcul. Et la blockchain bien évidemment dans ce cas-là va rajouter du bénéfice car la blockchain est décentralisée.

Meriyem : et comment ?

Daniel Yasri : Alors ça s'est très compliqué. Je ne sais pas si je serais te l'expliquer. La blockchain, via des nœuds décentralisés, elle se met directement dans ce process de cross computing et de décentralisation. Si par exemple, je veux mettre l'IA en réseau. Tu peux directement te dire je vais la mettre sur mes nœuds blockchain comme ça je gagne en puissance de calcul mais je gagne aussi en vitesse de multiplication de départage parce que comme tu le sais, la blockchain c'est plusieurs nœuds qui sont tous synchronisés.

Donc elle n'a pas besoin de demander à chaque fois à sa voisine, est-ce que t'es d'accord avec moi puisque la blockchain est décentralisée donc tu gagnes ce temps d'avance. Mais à tu rentres dans des considérations méga compliquées. Parce que le nonce du bloc, peut déjà permettre à l'AI de savoir que son pote y est déjà arrivé. Donc il n'a pas besoin de faire le calcul. C'est ce qu'on appelle des générations. Tu fais une première génération, une deuxième qui essaie d'aller plus loin, etc etc et c'est comme ça que les AI apprennent. Quand ils arrivent à une génération qui fait un mauvais point, on change de génération, on regarde ce qu'une autre a fait, et essaye de prendre un autre chemin etc. Et la grâce à la blockchain qui est décentralisée, et qui a par exemple tel bloc sur un autre bloc etc, il pourrait savoir que tel génération a déjà raté avant de commencer lui de faire la même erreur à l'avance. Donc tu vas aller beaucoup plus vite dans ton processus d'apprentissage. Mais je pense que c'est beaucoup trop compliqué.

Meriyem : Et les joint décision, c'est lié ?

Daniel Yasri : Oui, sur la même base que sur ce que je viens de te dire. La blockchain est toujours d'accord entre eux, la joint décision est plus facile que si tu as 25 avis différents. Et tu peux savoir si tu es en synchronisation par rapport à l'autre ou pas sans avoir à demander, refaire tous les calculs etc pour arriver au même point vu que tu sais déjà que t'y es vu que c'est certifié. La blockchain dit oui je suis là, je suis au bloc numéro 6.

Meriyem : D'accord, merci beaucoup pour toutes ces informations.

Daniel Yasri : Avec plaisir, n'hésite pas à me recontacter si tu as une question ou autre.

Meriyem : D'accord, c'est super gentil, si j'ai besoin d'éclaircir quelque chose, je te contacterai.

Daniel Yasri : Parfait.

Meriyem : Encore un grand merci. Bonne journée à toi.

Daniel Yasri : A toi aussi, au revoir.

Interview Emmanuel Goffi – Philosophe AI

Meriyem : Bonjour Monsieur Goffi.

Emmanuel Goffi : Bonjour Meriyem.

Meriyem : Merci d'avoir accepté de passer 30 petites minutes à répondre à mes questions.

Emmanuel Goffi : Avec plaisir.

Meriyem : Pour me présenter brièvement, je m'appelle Meriyem et je termine mon master en ingénieur de gestion avec un mémoire sur l'intelligence artificielle et la blockchain. Tout ça dans le domaine de la santé. J'ai regardé, analysé un peu tous les problèmes éthiques qu'ils pouvaient avoir à ce niveau-là. Pour ça, j'ai fait plusieurs interviews avec des spécialistes de l'intelligence artificielle, de la blockchain, que ce soient des médecins qui s'y intéressent. Ce que je voulais, moi, c'était clôturer les mémoires avec le point de vue d'un philosophe pour justement avoir maintenant quelque chose de différent et d'avoir une ouverture sur le sujet. C'est intéressant de voir qu'est-ce qu'il en est de l'intelligence artificielle dans le futur, dans la société ou les gens qui les citoyens ont des inquiétudes par rapport au fait que ça va remplacer leur travail, comment la société va se comporter dans le futur. Si maintenant on a des humains qui sont mis robots mi humains, qu'est-ce qui va se passer si on habite en symbiose avec énormément de machines ? Et donc, c'était plus pour terminer sur quelque chose dans ce style-là. Après, vous avez sûrement beaucoup plus d'informations que moi. Si on peut commencer avec une question générale, qu'est-ce que vraiment l'intelligence ? Peut-on dire l'intelligence, est-ce qu'on peut dire qu'une machine intelligente, au même titre qu'un cadre humain, est-ce qu'elle peut avoir une conscience,...

Emmanuel Goffi : Alors, je n'ai pas vraiment de réponse, ce serait trop simple. Le problème qu'on a avec l'intelligence artificielle, en règle générale, c'est qu'on utilise des termes qui sont indéfinissables quand on parle d'intelligence artificielle. Premier problème fondamental c'est que l'intelligence, on est incapable de le définir. On n'est déjà pas capable de le définir pour un être humain, ce qu'est l'intelligence. Il y a des personnes qui vont considérer que l'intelligence ça se mesure avec le QI, il y a des gens qui vont parler d'intelligence émotionnelles, d'intelligence situationnelle, il y a toute une gamme d'intelligence. Globalement, l'intelligence est très difficile à définir. Chacun a sa propre définition. Donc selon que vous avez une définition ou une autre, bien évidemment, votre perception de la possibilité d'une intelligence artificielle peut être positive ou négative. Moi, je ne suis pas négatif. Je pense que oui, je suis certain qu'on peut à un certain degré pour le moment, évidemment, dupliquer ce qu'on appelle l'intelligence humaine. J'entends par l'intelligence et la mobilisation de connaissances pour faire des inférences et ensuite, résoudre des problématiques spécifiques. On est plus dans du situationnel. Mais malgré tout, avec un certain nombre de connaissances qui sont derrière ça, c'est mon interprétation. Je pense, est tout à fait capable aujourd'hui d'envisager qu'à un moment donné, les machines auront ces capacités cognitives qu'ont les êtres humains. Ça va très, très vite. Il y a beaucoup de gens qui balaie d'un revers de main. Moi, ça m'inquiète parce qu'effectivement, on peut considérer que ce n'est pas demain qu'on aura un type puissant comme terminator qui va débarquer dans nos salons. Mais même si ce n'est pas demain, c'est dans 50, 100 ans ou 150, ça ne nous interdit pas de penser et d'anticiper cette

situation. Moi, ce que je fais, c'est le parallèle avec l'environnement. Pendant des années, depuis les années 70, 80, on s'inquiète des questions climatiques. Et puis, tout le monde disait ce n'est pas grave, ce n'est pas pour maintenant. C'est le jour où on se retrouve dans une situation qui est catastrophique, à savoir cet énorme trou dans la couche d'ozone. On se dit qu'est-ce qu'on fait. Qu'est-ce qu'on fait quand on est face au mur, c'est un peu tard. Ça ne veut pas dire qu'on ne peut rien faire. Ça veut dire que globalement, si on s'était pris un petit peu avant, si on avait anticipé, réfléchi, je pense qu'il n'y a pas de réponse. Est-ce que ça existera? Est-ce que ça n'existera pas? Mais il ne faut surtout pas s'interdire de penser à tous les scénarios. Ça, ça me paraît fondamental. Mais aujourd'hui, même les scénarios les plus loufoques, les plus science-fiction possibles. Je pense que c'est très important de se poser cette question maintenant parce que ça va aller très vite, parce qu'on sait très bien que ça va de plus en plus vite et que très rapidement, ça va nous échapper. Ça nous échappe déjà d'une certaine manière. Donc oui, je pense qu'évidemment, des gens vous diront on sera 2045. Je ne crois pas personnellement, mais en tout cas, même si dans 50 ans, 60 ans sortant, oui, bien sûr que la technologie sera capable d'avoir ces capacités cognitives. Est-ce qu'elle sera capable d'avoir une conscience d'elle-même? Certainement que oui, certainement. Il n'y a pas de raison. Donc, oui, tout ce qu'on voit dans les films de science-fiction sur des machines qui s'auto déterminent, sur, par exemple, Irobots avec Will Smith. Je pense que c'est quelque chose qu'il faut envisager. Personne ne peut dire ça n'existera pas. Personne ne peut dire que ça existera. Tout ce qu'on peut dire, c'est ça fait partie du possible. Alors autant y réfléchir maintenant, autant se questionner avec une question de fond qui, à mon avis, fondamentale sur les questions de l'intelligence artificielle et l'éthique, c'est de se dire quel type de société on veut. Vers quel type de société on veut s'orienter. Si on veut s'orienter vers une société extrêmement technologique où, finalement, l'être humain n'a plus grande importance. Si on considère que vous parliez d'êtres humains, cyborg, mi-homme, mi-machine? Si pour certaines personnes c'est l'avenir de l'humanité. Moi, je ne vois pas de souci. Je n'ai pas à juger de ça, mais il faut qu'on se mette tous d'accord pour dire oui. On va dans cette direction, dans cette direction ou éventuellement dire quelles sont les limites qu'on ne peut pas dépasser. Donc, la première lors des questions, je pense, c'est de s'interroger sur quel modèle de société on veut pour demain. En philosophie, je trouve très intéressant le travail de Jonas sur le principe de responsabilité qui dit il faut faire en sorte de ne pas mettre en danger la survie de l'espèce humaine. Mais même ça, ça peut se questionner. On peut très bien dire, à la limite, peut être que demain, ces fameux robots qui seront conscients d'eux même qui auront une autonomie de penser que c'est finalement la continuité de ce qu'on appelle l'être humain aujourd'hui. Peut-être que demain, l'être humain ne sera plus de chair et de sang. Il sera peut-être fait par des algorithmes et avec du hardware. Moi, je n'en sais rien et personne n'en sait rien. Mais en tout cas, première question à se poser c'est vers quoi on veut aller? Et puis, en quoi on ne veut pas aller en termes de société. Et puis ensuite, c'est surtout, surtout, je l'entends très souvent et je le déplore, de ne pas balayer d'un revers de main la possibilité peut être loufoque pour certains, d'avoir effectivement de voir des Terminator qui vont se battre, d'avoir Skynet qui va prendre le pouvoir. Je n'en sais rien, je n'en sais rien d'ailleurs. Juste pour information, peut être que vous le savez. Le ministère de la Défense, par exemple, a recruté des experts de science-fiction pour imaginer des scénarios de conflits, de combats, de l'avenir, mais qui sont complètement hors de la rationalité ou de ce qu'on peut avoir. Donc, si on fait l'armée, je crois qu'on ne ferait pas pour la société en général.

Meriyem : En parlant des sociétés, c'est quoi les inquiétudes qu'il y a aujourd'hui autour de cela ?

Emmanuel Goffi : L'inquiétude ultime, c'est celle qui a été émise par des gens comme Stephen Hawking, puis Elon Musk. C'est vraiment une menace existentielle. C'est là où ça revient à Jonas. Moi, je ne suis pas un spécialiste d'intelligence artificielle sur le plan technologique. Mais quand quelqu'un comme Stephen Hawking dont on ne peut pas nier le génie, dit qu'il faut faire attention parce que potentiellement, cette nouvelle technologie peut marquer la fin de la race humaine, ou en tout cas de l'humanité. Je pense qu'il y a des raisons de s'inquiéter. Donc ça, c'est la menace ultime, c'est de dire d'avoir d'abord des systèmes qui vont s'autodéterminer, puis qu'à un moment donné vont se dire finalement ce bonhomme de chair et d'os qui est pas très utile. Et pourquoi on ne l'exterminerait pas pour qu'on passe à autre chose. C'est très Science-Fiction, j'en conviens. Pour l'instant, c'est très Science-Fiction. Mais en tout cas, ça, c'est vraiment la menace ultime. Puis à un moment donné, les machines, prennent le contrôle, estiment que l'être humain tel qu'on le connaît aujourd'hui n'est plus utile. Soit, elle, le réduise à un état de servitude quelconque, soit carrément le détruise, considérant que ce n'est pas intéressant. Soit le renvoi, comme on renvoie les animaux, à des simples phénomènes de foire comme dans des zoos ou pourquoi pas, l'être humain serait un animal parmi d'autres pour ces machines. Ça, c'est la grosse place. Après, il y a des menaces qui sont plus pragmatiques, plus pratiques, parce qu'elles sont réelles, qui sont sur le respect d'un certain nombre de valeurs ou de principes qui sont très variables. Là aussi, il faut faire attention. Le mot valeur est très difficile à définir et très souvent, ce qu'on voit en termes de, par exemple, de violation de valeurs par l'intelligence artificielle, comme par exemple la vie privée, les droits de l'homme, la transparence, l'explicabilité, etc. Tous ces principes dont on entend parler régulièrement sont des principes qui sont extrêmement occidentalocentrés, sur des principes qui ne va pas forcément de résonance en Asie, qui n'ont pas forcément de résonance en Afrique et d'ailleurs, qui sont des non-problèmes. Donc, là aussi, quels types de valeurs sont violés par l'intelligence artificielle ? Quand on parle typiquement de la vie privée, il est clair que c'est une inquiétude. Par exemple, en Europe, c'est marqué dans le RGPD. Ça peut être une inquiétude en Amérique du Nord, c'est pas du tout un problème en Chine, parce que la notion même de vie privée n'est pas la même quand on est confucéen ou quand on est judéo chrétien. Ce n'est pas la même quand on est dans un pays asiatique, dans un pays occidental. Très récemment, on l'a vécu avec une amie qui était au Maroc parce qu'on fait un travail là-dessus. Elle nous disait que dans l'islam, les questions d'éthique que nous, on se pose en Occident, sont absentes. Parce que parce que l'on ne questionne pas l'acceptabilité ou la non-acceptabilité de décisions qui sont prises par une autorité, d'autant plus que le droit est fondamentalement marqué religieusement, dont on ne conteste pas la religion. On ne conteste pas les autorités religieuses. Donc, là aussi, les perspectives sont un peu différentes. Donc les menaces qu'on peut voir aujourd'hui de l'intelligence artificielle sur les droits de l'homme, qui ne sont pas universelles non plus. Sur la vie privée, sont des inquiétudes qui sont somme toutes très limitées. Il y a une autre inquiétude sur les biais à travers des milliers de genre, de couleur, de statut social qui, là aussi, sont des sources d'une problématique schizophrénique occidentale. En Arabie saoudite, la question du biais de genre, tout le monde s'en moque. En Inde, la question du biais de statut social, tout le monde s'en moque. C'est un système casté. Il est clair qu'en Chine, tout le monde s'en moque. Il est clair qu'en Corée du Nord, tout le monde s'en moque. Il y a tout un endroit où les biais de genre, les biais de couleur et de statut social, ce sont des non-problèmes. Ce sont des choses sur lesquelles on ne se questionne même

pas. Encore une fois, on transpose un petit peu, nos angoisses, nos stress. Nos inquiétudes, légitimes ou pas. Ce sont toutes ces inquiétudes, que j'aurais tendance à dire, à mon sens en tout cas, qui sont finalement très limitées géographiquement et très limitées culturellement aux Occidentaux. Et encore pas tous les Occidentaux. Si vous allez en Hongrie, si vous allez en Bulgarie, vous êtes dans les ex-pays communistes. Les questionnements sur les biais de genre, ce n'est pas vraiment leur truc. Il faut être honnête sur les biais de couleur, ce n'est pas non plus vraiment leur truc. Donc, on est vraiment sur quelque chose qui fondamentalement et philosophiquement extrêmement, extrêmement limité.

Emmanuel Goffi : C'est intéressant. Les problèmes que vous dénoncez là maintenant, c'est ceux que moi, j'ai relevé évidemment dans une partie de mon mémoire, puisque c'est celles qui ressortent tout le temps dans la littérature. Après, j'ai fait une partie sur les pays émergents et évidemment, les problèmes et les inquiétudes ne sont pas exactement les mêmes. Oui, c'est intéressant.

Meriyem : C'est un des soucis quand on travaille sur ce domaine-là. Moi, je suis très constructivistes dans la manière de penser. Mais en tout cas, ce n'est pas la théorie, c'est un processus de réflexion, mais je pars du principe très simple que nous sommes tous le produit des interactions qu'on a avec notre environnement. En soi, les gens avec lesquels on discute, soit notre culture, notre environnement socio professionnel, peu importe. En tout cas, on est tous marqué et influencé par tout ça, bien évidemment. Et quand on est en Europe et qu'on travaille sur l'éthique de l'intelligence artificielle, la plupart du temps, on est déjà baigné d'a priori sur cette question-là parce qu'on a entendu un certain nombre de choses dans notre environnement, parce que finalement, on ne se réfère, sauf à être polyglotte, à un corpus extrêmement étroit de documents dans les langues qu'on maîtrise le français, l'anglais, l'italien. Mais ça va s'arrêter là. Donc, globalement, c'est très européen. Je suis incapable de lire le mandarin. Je ne peux pas lire l'arabe classique. Je ne peux pas lire le russe, ce qui veut dire que, finalement, pas accès à ces sources de première main. Certaines sont traduites, mais la plupart ne le sont pas. Donc, ça veut dire que là aussi, ça referme d'autres perspectives et finalement, on retrouve toujours les mêmes problématiques. Et ça, c'est quelque chose que je déplore dans cette réflexion sur l'IA. C'est qu'on retrouve toujours les mêmes personnes qui parlent toujours des mêmes choses en se fondant toujours sur les mêmes arguments. Ici, c'est relativement pauvre parce que quand on va chercher au-delà, quand je discute avec les Chinois, quand je suis avec des Indiens et quand je discute avec des musulmans, quand je discute avec des juifs, quand je discute aussi parce que je vivais au Canada avec des Premières Nations et des aborigènes en Australie, leur rapport à la nature, le rapport à la technologie n'a strictement rien à voir avec les problématiques que nous, on se pose en Occident. C'est là où cette diversité génétique est fondamentalement importante. Donc, c'est problématique que vous nous ayez identifiés sont des problématiques qui sont tout à fait classiques. On retrouve un petit peu partout, mais il faut avoir conscience qu'elles sont très marquées culturellement et je vous dirais même que quand vous retrouvez ces problématiques, parce qu'on va les retrouver. Par exemple, dans un certain nombre de documents qui ont été émis par la Chine. On retrouve ces principes de la transparence des droits de l'homme. Ce n'est pas que la Chine a pour valeurs le respect des droits de l'homme. En tout cas, pas au sens où on l'entend. C'est parce que la Chine veut pénétrer le marché européen et qu'elle sait très bien que si elle veut pénétrer le marché européen, elle est bien obligée de montrer qu'elle suit les règles qui sont demandées. L'ensemble des documents qui sont

édités par ces organismes, par ces pays qui ont des valeurs complètement différentes, ce n'est pas une communauté de valeurs, c'est simplement du pragmatisme en disant si je ne montre pas, je le dis d'autant mieux que je suis consultant pour huawei et je fais de la standardisation éthique pour huawei. Pour moi, oui. Ce n'est pas que les Chinois soient pétris de droits humains, ce n'est pas ça. C'est qu'ils savent très bien que s'ils veulent pénétrer ce marché, qu'ils peuvent faire, je ne sais pas, plus de 500 millions de consommateurs en Europe. Eh bien, il va falloir qu'ils acceptent un certain nombre de règles, un certain nombre de standards. Donc, si c'est là, encore une fois, où je m'aperçois que cette différence d'éléments qui relèvent de l'éthique, bien sont le fait d'une extrême minorité de l'individu qui sont fondamentalement des Occidentaux. Je finirai juste par un exemple très récent. J'ai vu passer il y a quelques jours un document qui est sorti par l'Organisation internationale du travail sur les questions d'éthique. Quand vous regardez ce travail, on parle de relations internationales du travail, d'accord. Quand vous regarder ce travail, Il a été fait par les Occidentaux, essentiellement d'ailleurs, des gens qui sont européens. Quand vous regardez les références, ce ne sont que des références, des biographies occidentales en français et en anglais. Et en fait, ce document se veut une espèce de guide sur l'intelligence artificielle pour l'ensemble du monde. Je ne vois pas comment c'est possible. Je ne vois pas comment c'est possible. Encore une fois, c'est quelque chose qui me qui m'échappe complètement. L'UNESCO a sorti un document sur les rapports entre l'intelligence artificielle et les enfants. Donc l'UNESCO, encore une fois, un organe des nations unies. Le lendemain, la Chine sortait un document de son propre chef sur la même problématique. Or, la Chine fait partie des Nations unies. S'il y avait une communauté de valeurs, alors la Chine n'estime pas nécessaire d'avoir un document à elle adhérerait aux principes de l'Unesco. Vous voyez, c'est nul. Cette complexité, c'est aussi de sortir de ses cadres. Du moins, c'est ce que j'essaie de faire. Et encore une fois, je ne suis pas très important. Quand je parle, je ne donne pas mon avis personnel. Je donne mon avis d'universitaire, je dis attention à cette tyrannie occidentale de l'éthique. C'est une problématique éthique. Je discutais avec un ami que j'ai rencontré à Bahreïn et disait dans une conférence mais vous avez de la chance, en Occident, vous avez le luxe de vous poser une question éthique. Nous, Proche-Orient, notre éthique, elle est limitée par une question de sécurité. Tout ce qui assure notre sécurité est moralement acceptable. J'avais vécu la même chose en Israël, c'est exactement ça. Si tout est mesuré à l'aune de cette sécurité, nous, on se pose des questions de gens riches, de gens qui ont de la chance, de gens qui vivent dans un environnement globalement assez agréable. Ces gens qui vivent au Proche-Orient, qui sont sous la menace permanente de leurs voisins et donc tous les moyens qu'ils vont mettre en œuvre, l'intelligence artificielle, par exemple, pour des systèmes militaires. Tout est justifié moralement par le fait qu'il faut survivre dans cet environnement hostile. Toutes ces perspectives-là, Il faut faire attention à ne pas les exclure. Quand on parle, par exemple, de biais de genre, il y a des raisons dans les pays occidentaux de se poser ce genre de question. Il n'y a aucune raison, à mon sens, de les imposer à des pays qui ont des perspectives de relations hommes femmes qui sont complètement rassurantes. Je n'adhère pas à ce que fait l'Arabie saoudite, mais je n'ai pas de légitimité occidentale à dire aux Saoudiens comment ils doivent vivre dans leur pays. De la même manière que je n'accepterai pas que les Saoudiens viennent me dire en France, toutes les femmes doivent porter un voile. Pourquoi moi, je le ferais dans l'autre sens que c'est ça aussi qui est très, très important dans ces questions d'éthique. C'est aussi des questions sur nos propres perceptions, sur notre propre perspective, de ce qu'est l'éthique.

Meriyem : C'est vrai que pour faire le travail, j'avais besoin de me concentrer sur un

framework, qui est celui de l'Union européenne qui en avait sorti un. C'est vrai qu'à chaque fois, les problèmes qui ressortent. C'est ce dont vous parlez, mais aussi ce qui est du coup drôle, entre guillemets, c'est que pour qu'une intelligence artificielle soit accréditée, elle doit suivre, elle doit compléter et rencontrer certaines conditions qui fait que, du coup, ça pourrait ne pas être les mêmes partout. Alors, comme vous dites, en Afrique, pourtant, on va aller leur apporter l'intelligence artificielle. À l'inverse, la Chine va créer une intelligence artificielle qui ne rencontrera pas les attentes de l'Union européenne. Et ça peut aussi poser des problèmes d'adaptation.

Emmanuel Goffi : Exactement, c'est un problème qu'encore une fois que j'ai avec huawei. Ils m'ont approché en me disant la chose suivante : il y a un organisme de standardisation en Europe, standardisation sur le plan légal essentiellement. Est ce qu'on suit les normes légales de l'Union européenne ? Et puis ensuite, ils se sont dit on a un autre problème, c'est plus GPD. Il y a un certain nombre de principes qui relèvent de l'éthique. Mais les Chinois ne maîtrisent pas ces principes éthiques. Eux, les droits de l'homme, pour la plupart des Chinois, ce n'est pas qu'ils ne veulent pas les respecter, c'est qu'ils ne comprennent pas le concept même. Ils ne comprennent pas l'idée. C'est le premier point qu'on m'a dit. Voilà, il faut que vous nous expliquer quels sont ces principes. Qu'est-ce que ça veut dire, vie privée, etc. Et puis ensuite, le problème que les Chinois ont encore une fois leur manière de penser, leur structure intellectuelle est différente de la nôtre. C'est que ce sont des gens qui sont fondamentalement pragmatiques. Nous, on se veut les héritiers des lumières. On aime bien penser un petit monde éthéré, mais comment se transforme le respect des droits de l'homme en algorithme ? C'est ça, la standardisation. D'un point de vue pratique, qu'est-ce que je fais ? Qu'est-ce que je fais ? Les droits de l'homme, c'est une question qui revient systématiquement dans les entretiens avec les groupes avec lesquels je travaille. C'est très bien les droits de l'homme. Oui, mais comment je les transforme en algorithme ? Comment je les opérationnalise ? Donc là, il y a une grosse difficulté aussi d'opérationnalisation de tous ces principes qui n'est pas propre à huawei. Il y a tout un tas d'organismes de standardisation européens qui ont exactement les mêmes difficultés de définition de comment j'opérationnalise en fonction du secteur, en fonction des objectifs. Et puis, un autre point qu'il faut, il faut aussi garder à l'esprit, c'est que l'Union européenne, c'est un cas très particulier. Là où j'attire votre attention dessus, c'est que l'Union européenne se veut un acteur normatif. Vous le savez, sur la question de l'intelligence artificielle d'abord, l'Union européenne a décidé que son créneau, ce seraient les normes légales, les normes morales. Les normes légales c'est très compliqué parce que l'intelligence artificielle évolue extrêmement vite, que le droit n'évolue pas extrêmement vite. Donc, c'est plus facile de faire appel à quelque chose qui est beaucoup plus flexible. Plus informel qu'est l'éthique. D'accord, on peut utiliser plus facilement. Mais ce qui est intéressant aussi, c'est que si vous regardez le RGPD, si vous regardez l'ensemble des documents qui ont été émis par l'Union européenne sur la question de l'intelligence artificielle, on voit clairement que le fil rouge, le fil conducteur de tout ça, c'est comment faire pour que l'Union européenne se positionne dans le groupe de tête des leaders en Intelligence artificiels parce que l'Union européenne n'est pas un ange. Ce n'est pas un Bisounours. L'Union européenne, les acteurs, la France, l'Allemagne, sont les grands acteurs. La France et l'Allemagne sont très conscients du fait qu'il y a une manne financière qui a des intérêts économiques phénoménaux. Derrière tout ça, il y a de la recherche et développement d'éducation. Il y a des questions diplomatiques, il y a du militaire. Il y a de la santé. Il y a plein de choses. Donc, tous ces enjeux, croyez-moi sur parole, parce que là aussi, je travaille avec l'Union européenne, sont bien plus haut dans

les priorités des dirigeants européens que les questions d'éthique. Et quand vous lisez le RGPD, on voit bien que le RGPD est aussi le fait d'une manière à être suffisamment souple, suffisamment flexible, suffisamment interprétables pour finalement ne contraindre véritablement personne. C'est à dire que quand on lit les principes du RGPD, effectivement, c'est pour ça qu'on a du mal à les opérationnaliser parce qu'ils sont tellement vagues, tellement larges que finalement, on peut mettre un petit peu ce que l'on a envie dedans. C'est quand même malgré tout l'objectif. Les documents le disent clairement, regardez, l'intelligence artificielle représente tant de milliards dans le domaine civil, tant de milliards dans le domaine militaire. Si on regarde les différents secteurs, bien il va y avoir tant d'emplois, etc. Etc. L'Union européenne est très consciente que derrière, il y a un enjeu économique et financier phénoménal. Elle ne veut pas ce contrat annuel, elle ne veut pas prendre les autres. Là aussi, les contraintes éthiques. Il faut aussi les prendre pour ce qu'elles sont. C'est une niche marketing, ça veut dire que l'Union européenne ne peut pas être compétitrice contre les Etats-Unis, ni contre la Chine, ni sur le plan technologique, ni sur le plan hardware et software. Du coup, elle a décidé que sa niche, ce serait la norme. Mais derrière, elle fait comme tout le monde. Tous les acteurs qui font la course à leur intelligence artificielle vont chercher une manne financière. Je regarde les documents, les documents français, les rapports des commissions parlementaires depuis une dizaine d'années. Systématiquement, systématiquement, c'est Regardez l'argent qui va être fait dans les 10 à 30 ans, regarder en 2060. Regardez le nombre de milliards qui vont être retirés du développement de cette intelligence artificielle. Regardez les atouts stratégiques qu'on peut avoir sur nos armements. Faut garder en tête qu'en Europe, un pays comme la France, évidemment, fait partie des cinq premiers exportateurs d'armes. Elle n'a aucun intérêt, la France a se limiter dans le développement sur l'intelligence artificielle en sachant que les armements de demain soient équipés d'intelligence artificiels. Là aussi, les principes éthiques, il faut les prendre pour ce que c'est. La question, c'est surtout de dire il faut bien comprendre que ces mots, ces principes, comme très souvent, sont relativement creux. C'est pour ça qu'il y a un tas d'acteurs qui se disent, nous on travaille avec Sapiens, avec des petites et moyennes entreprises. Et les patrons d'entreprises vous disent déjà le RGPD patron d'une petite entreprise, ce n'est pas envisageable de le comprendre, c'est normal, ils n'ont pas les moyens de se payer un juriste pour le faire. Et puis quand même, ils le font. Des fois, ils disent qu'on ne sait pas quoi faire avec tous ces principes de beaux principes. Mais au quotidien, comment je fais. Parce que certains principes vont à l'encontre de l'intérêt de grandes entreprises qui est quand même de faire du bénéfice malgré tout, de participer au PIB français, donc à la croissance française. Qu'est-ce que je fais si je respecte effectivement, par exemple, les données privées ? Si je respecte cette question des données privées, je vais limiter les ressources de mes algorithmes, limiter l'efficacité de l'intelligence artificielle. Pendant que les Chinois ont développé certainement ou les Américains des outils qui seront beaucoup plus efficaces. Résultat des courses ? Moi, je veux être compétitif, ou alors il va falloir que je déporte une partie de mes travaux dans des pays qui sont moins contraignants sur le plan normatif. Bref, on se retrouve dans des situations extrêmement compliquées. C'est ça qui est important, c'est bien que ces principes, ce sont essentiellement des arguments marketing. Pas de conviction profonde, loin s'en faut.

Meriyem : Il y avait deux questions, mais la première, c'est que vous avez quelque chose par rapport au fait qu'il y avait un manque de confiance dans l'intelligence artificielle et du coup, ils disaient que ça ne pouvait empêcher le développement et l'adoption dans le

futur. Il y aurait quelque chose comme ça qui pourrait empêcher justement le développement ?

Emmanuel Goffi : Il y a plusieurs choses dans votre question, la première. La première chose, c'est cette idée de trustworthy AI. Et vous le savez aussi bien que moi, qui fait justement quand on parle de trustworthy AI, l'Union européenne a travaillé là-dessus, d'ailleurs. C'est de dire il faut recréer de la confiance. Et il y a un objectif derrière qui, encore une fois, ce qui est de dire faut que derrière, les consommateurs adhèrent. Si on développe des produits ou des solutions AI et que personne ne les achète parce que les gens n'ont pas confiance, surtout que les gens ont un doute. Ça ne sert à rien. D'accord, globalement, ça a aucun intérêt. Donc il faut que les gens adhèrent. Il faut que les gens achètent et donc il faut rassurer. Il y a tout un discours éthique, ce que j'appelle du cosmétique. On essaye de maquiller un petit peu ce qui est inacceptable. Ce cosmétique qu'on est en train de bâtir, ce discours cosmétique passe aussi par l'utilisation de mots qui sont très, très précis. Quand je vous dis une intelligence de confiance, je conçois, je convoque implicitement votre confiance. Si je vous dis voilà, je développe une intelligence artificielle qui est éthique et de confiance pour le français moyen et sans être péjoratif. Je fais partie des français moyens dire OK, tout va bien. Non seulement c'est éthique, mais en plus c'est un truc de confiance. Il y avait également cette notion de confiance. Il faut faire très attention. Et ensuite ? De mon expérience parce que j'ai travaillé sur la question quand j'étais militaire, sur la question des systèmes létaux autonomes et des drones en particulier. Il faut savoir qu'au fur et à mesure, il y a eu une acculturation de la population à ces systèmes. C'est à dire que ce qui paraît aujourd'hui un peu inquiétant pour la plupart des Français ou la plupart des Européens, demain, sera nettement moins. Quand j'ai commencé à travailler sur la question des drones. La France avait des drones. Les Etats-Unis utilisaient leurs drones au Pakistan de manière un peu discutable de la CIA. Il y avait tout un débat. Il ne fallait pas de drones, ce n'était pas bien, assez inquiétant, etc. Aujourd'hui, c'est devenu un autre problème. Mais quand je vous dis, quand j'ai travaillé, quand j'ai commencé à travailler dessus, c'était en 2010. C'était il y a dix ans. Donc, en dix ans, le drone est devenu un objet tout à fait banal. Et personne ne se pose la question du fait que le président Chirac avait dit : nous n'aurons jamais de drones armés et qu'aujourd'hui, on utilise des drones armés dans la bande sahélo saharienne. Personne ne se pose la question, donc l'acculturation à la technologie, elle, se fait peu à peu. L'acculturation aux solutions d'intelligence artificielle se fait peu à peu. J'ai un fils qui a 20ans, on discute beaucoup de ces choses-là. Et puis, il est juste fasciné par le fait que quand tu prends son téléphone avec son téléphone, il ne se pose pas de questions auxquelles mes données privées, c'est la facilité avec laquelle on peut interagir avec notre environnement et comment cette intelligence artificielle nous facilite ces interactions. Donc, ça veut dire que lui est déjà acculturés a des choses auxquelles moi, je ne suis pas nécessairement acculturé. Donc moi, je pense que dans une génération de deux générations, la question sera une non question. Tout le monde utilise déjà tous de l'intelligence artificielle sans se poser de questions. Globalement, ce sont des algorithmes, quand vous avez des recommandations sur Amazon, sur Netflix ou peu importe derrière il y a des algorithmes. Je ne vois pas. Et moi, le premier, je ne me pose pas la question. Qu'est ce qui se passe. L'acculturation à l'intelligence artificielle Elle se fait de deux manières. D'une part, par le fait que ça devient quelque chose de normal dans notre environnement, donc on s'y habitue. Et puis autre chose. Mais ça, c'est très philosophique. C'est ce qu'on appelle la gouvernementalité. C'est aussi tout ce discours, cette technologie du gouvernement qui est mise en place soit par des acteurs privés, soit des acteurs publics

pour faire en sorte de faciliter cette acculturation. Ça va être un discours, ça va être un certain nombre d'outils qui vont être utilisés, de réglementation. Ce qui aujourd'hui est une inquiétude. Là, je fais le pari ou on se retrouve, on en discute en disant que ce ne sera plus du tout un problème.

Meriyem : Maintenant, si une machine aide à faire un diagnostic où fait le diagnostic elle-même les patients, dans les enquêtes d'aujourd'hui, ils n'auraient pas tendance à ne pas croire. Mais dans 5 à 10 ans, ça peut devenir banal. C'est un non problème alors.

Emmanuel Goffi : Bien sûr, on travaille avec le Big Data Lab de l'Université Goethe à Francfort. On travaille sur deux cas d'éthique, un process d'évaluation normatif et outils d'intelligence artificielle. On est sur deux cas d'étude sur un premier cas qui est un cas de détection des risques d'arrêt cardiaque par des opérateurs téléphoniques. Vous appelez ? Il y a quelqu'un qui est en train de faire un arrêt cardiaque. Donc un opérateur va évaluer le risque d'arrêt cardiaque. Un organisme qui a développé un algorithme, un logiciel d'appui à ces opérateurs qui, globalement, augmente de 10% les chances de détecter la possibilité d'un arrêt cardiaque. Il faut savoir que les opérateurs eux-mêmes, quand l'algorithme leur met une alerte en disant attention aux risques, les opérateurs eux-mêmes ne croient pas pour le moment, c'est à dire ils ne font pas confiance et n'ont pas confiance en cette alerte. Mais ce qui va se passer, c'est que malgré tout, que cet outil va être implémenté parce que globalement, vous avez dix pour cent de chances de sauver des gens en plus, ce qui est négligeable. Ça va être mis en place. Et puis les gens vont commencer à l'utiliser, puis ça va être utilisé. Donc il y a une certaine réticence au départ. Et puis, il y aura moins de réticences demain. Si je reprends mon cas des drones dans l'armée de l'air, j'étais officier dans l'armée de l'air. Les drones, les officiers ne voulaient pas entendre parler de nouveau, et notamment les patrons de l'armée de l'air, qui sont des pilotes ne veulent pas en entendre parler. Parce que dans l'esprit des militaires de l'armée de l'air, le drone, c'était la fin du pilote. C'est la fin de cette élite qui dirige l'armée de l'air. Et donc, il y avait tout un tas de gens qui étaient complètement contre. Aujourd'hui, dix ans après, les nouvelles générations sont complètement acculturées à ça. On a développé tout un discours. J'ai travaillé pour la décode sur la communication. Autour de ces sujets, on a développé tout un discours extrêmement rassurant qui fait que les gens sont habitués. Donc dans le domaine médical, ce sera exactement la même chose. Il y aura toujours des réticences. On aura toujours des blocages. On aura toujours des gens qui s'inquiéteront, mais on ne va pas si vous voulez, ce n'est pas une révolution, c'est pas une bascule de demain tout fait par l'intelligence artificielle. C'est petit à petit dans l'environnement des gens qui travaillent dans le monde médical, on va retrouver des algorithmes pour retrouver de l'intelligence artificielle. Et puis, petit à petit, ça va devenir quelque chose de commun. Ça va devenir quelque chose de normal. Donc il y aura systématiquement, quand on mettra en place peut être un nouveau système, de nouvelles solutions, il y aura deux ou trois réticences au départ, mais c'est vraiment au départ parce qu'une fois que s'est implémenté. Et puis, les gens s'habituent à l'utiliser comme c'est déjà le cas. Il y a déjà de l'IA dans le monde médical. Il y a déjà des accompagnements à la réflexion, avec ce genre de choses, parce que c'est sur la détection des cancers de la peau. On vous expliquera que oui, mais ça sauve des vies. N'importe quel médecin, n'importe quel infirmier ou n'importe quelle personne dans le monde médical ne pourra pas argumenter moralement contre le fait qu'on va sauver des vies, on pourra dire je n'ai pas confiance. Mais si on vous dit oui, mais ça augmente de 10 les chances de survie de quelqu'un qui appelle pour un arrêt cardiaque potentiel. Comment moralement dire,

malgré tout, je ne veux pas. C'est très compliqué, donc il y aura tout un argumentaire qui va être fait. Il y a tout un discours qui est fait autour de tout ça, des gros soucis derrière.

Meriyem : Mais par rapport au danger qu'on entend aujourd'hui, par exemple, simplement avec la voiture complètement autonome. Ici, il y a les dangers d'une vie qui rentre en considération. Peut-être que l'adaptation peut être aussi plus compliquée dans ce genre de secteurs. Ou par exemple, si un robot décide de donner un médicament, mais qui donne un médicament qui fluidifie le sang alors que la personne peut en mourir.

Emmanuel Goffi : Oui, mais entre vous et moi, ce n'est pas des problématiques reliées à l'intelligence artificielle. Il y a des erreurs humaines qui sont faites quotidiennement sur ce genre de choses. Donc moi, je sais que sur la voiture autonome, on parle systématiquement de ce dilemme du trolley. Vous avez certainement entendu parler. C'est un dilemme typiquement humain et il n'y a pas de solution. C'est pour ça que ça s'appelle le dilemme. Quelle que soit la solution que vous prenez, elle ne sera pas nécessairement bonne. L'intelligence artificielle, on ne peut pas créer quelque chose qui dépasse l'entendement humain. On crée des choses qui correspondent à ce qu'on est capable de faire. Et ces dilemmes qu'on voit et risques qu'on voit dans l'intelligence artificielle sont des dilemmes et des risques qu'on va retrouver dans l'être humain. Sauf que l'on ne veut pas l'imaginer parce qu'on pense, et ça, c'est vraiment un tropisme très technologique, on s' imagine que la technologie va nous permettre finalement de compenser tous les défauts de l'être humain. On pense que la technologie, c'est la panacée. Et donc, quand on nous montre que cette technologie n'est pas une panacée et qu'elle a des défauts et qu'elle a des failles, tout de suite on s'en insurge, mais toute technologie a des failles, toute technologie a des failles. Évidemment qu'il y a des risques que on n'administre pas le bon médicament, mais un être humain peut faire la même chose. La question, c'est de savoir est ce que la probabilité pour que ça arrive par la technologie est plus élevée ou moins élevée que pour que ça arrive par rapport à un être humain? Et la plupart du temps, ce qu'on voit, c'est que les calculs de probabilités montrent que la technologie est malgré tout plus efficace. Mais je pense vraiment que dans notre imaginaire et dans le monde médical comme dans le monde militaire, parce qu'on touche à l'humain, parce qu'on touche à la souffrance, parce qu'on touche à la vie. On s' imagine que l'IA va être une solution parfaite, c'est à dire tant qu'on ne le dit pas, c'est un peu comme les produits de nettoyage, ça vous enlève 99,9 des virus tant qu'on ne dit pas 99,9. Ah, mais c'est l'IA. Mais l'être humain lui-même est faillible. L'être humain est faillible, donc. Donc l'IA, elle permet d'améliorer. L'IA n'est pas parfaite. L'IA n'est pas la solution à tous nos problèmes. L'IA ne résoudra pas toutes nos inquiétudes. L'IA supprimera pas tous les biais intellectuels. L'IA sauvera pas toute une vie, mais en tout cas, on croit qu'elle va accroître les probabilités de réussite dans un certain nombre de domaines dans le monde médical, c'est notamment le cas. Là aussi, c'est une perception sur l'IA. Vous avez des gens qui ont peur de la technologie. Je pense que des générations plus âgées qui soient plus réticentes, plus de médecins qui ont plus l'habitude, effectivement du contact. Il y a tout un tas de gens aussi qui sont, qui sont pétris de principes sur le contact humain, c'est le contact physique ou la peine de toucher, capable de voir, capable d'interagir. Ils sont très attachés à ça parce qu'ils ont été élevés comme ça, d'un point de vue constructiviste, qui ont beaucoup de difficulté à dire, à accepter qu'une machine le fasse à leur place. Mais voilà, c'est la tendance, qu'on le veuille ou non, pour lutter l'insurgé. Mais la tendance est là.

Meriyem : C'est un peu la peur de voir son métier être remplacé également.

Emmanuel Goffi : Bien sûr, comme je le disais pour les pilotes de l'armée de l'air. Tout le monde avait peur que les pilotes soient remplacés par des drones. Mais même au-delà de ça, parce que les pilotes sont l'élite de l'armée de l'air et donc les chefs de l'armée de l'air à tous les grands généraux ou les grands patrons sont des pilotes de chasse en particulier. C'était aussi finalement la fin de cette élite. Donc, il y a toujours, évidemment, une espèce de phénomène de repli identitaire. Mais moi, je ne vois pas ça parce que c'est menaçant pour ce que je suis. Je comprends qu'un médecin qui a fait des années d'études, qui accumule des années d'expérience, qui a vécu des expériences d'ailleurs parfois très, très difficiles, très traumatisantes, ne puisse pas imaginer qu'on me dise demain ta décision, elle peut être remplacée par une machine. Je conçois parfaitement. Je le conçois parfaitement, mais encore une fois, il faudra rediscuter dans 10 ans, voir comment les nouvelles générations, parce que ça va faire partie, ça fait déjà partie aussi des formations des nouvelles générations à ces questions d'acculturation à la technologie, l'utilisation d'interfaces intelligence artificielle, d'algorithmes, etc. Les nouvelles générations ont déjà dans leur formation, elles sont acculturées. Elle va arriver dans les hôpitaux où il y aura du matériel qui sera là, qui fonctionnera avec ça. Donc, ce qui est une question aujourd'hui ne sera pas une question demain. C'est comme ça que ça fonctionne.

Meriyem : Mais pour venir un petit peu avec le fait d'utiliser la blockchain, par exemple, comme vous avez dit, l'IA a un problème d'explicabilité, de savoir expliquer comment la décision a été prise, pourquoi elle a été prise et donc avec une solution blockchain, si elle pouvait enregistrer les décisions, on pourrait revenir en arrière, voir tous les steps et voir quelle décision a été prise, comment elle a été prise. Ça permettrait d'une part d'améliorer l'intelligence artificielle dans le futur et aussi ça permettrait de donner l'explication à un patient. Pourquoi on dit qu'il a un diagnostic ou un docteur, comment la décision a été prise. Est-ce que c'est vraiment utile ? Est-ce que c'est quelque chose qui peut améliorer la confiance, selon vous ?

Emmanuel Goffi : Moi, je pense. Encore une fois, c'est un faux problème. L'explicabilité, c'est un faux problème pour deux raisons. Déjà parce que pour que quelque chose soit explicable, il faut que la personne à qui vous l'expliquer soit capable de comprendre. Je me répète parce que je suis un peu vieux, mais systématiquement, je dis la même chose. Quand je vais chez mon garagiste, il me dit tiens, monsieur, il faut changer, je ne sais pas votre courroie de distribution et ouvre le capot moteur et m'explique par le détail pourquoi, il peut m'expliquer ce qui peut être le plus précis du monde. Je n'y comprends rien. Je n'y connais rien. Quand je vais chez mon dentiste et qui m'explique par le menu ce qu'il va faire, il peut me dire tout ce qu'il veut dans tous les cas de figure, je ne sais pas, donc il y a déjà un premier problème, c'est de savoir ce que les gens expliquent, sont capables de le comprendre. Ensuite, l'explicabilité, est problématique pour l'intelligence artificielle. Elle le sera pour la blockchain de la manière, de même qu'elle est compliquée pour un être humain. Allez demander à un médecin, des fois, d'expliquer pourquoi il a fait tel ou tel diagnostic. Pourquoi il a pris telle ou telle décision. Ce n'est pas nécessairement un processus de réflexion rationnelle. Des fois, il y a de l'émotion. Des fois, il y a du ressenti, des fois, une expérience. Parfois, les gens, quand ils prennent des décisions, sont incapables de refaire le fil de leur décision. Ils sont incapables de vous l'expliquer. Et quand bien même dans la blockchain, vous avez effectivement ces petits blocs dans lesquels on va fixer un certain nombre de choses et puis, chronologiquement, capable de

remonter. Ce n'est pas parce que vous avez cette chaîne chronologique que vous êtes capable de comprendre la logique qu'il y a derrière. De la même manière, si je vous disais voilà la fin de notre discussion, je suis capable de vous expliquer comment on est passé de tel sujet à tel sujet parce que on a enregistré. Puis je suis capable de refaire, mais vous n'en savez rien parce que vous ne savez pas ce qui se passe dans ma tête. Ce n'est pas les afférences que je fais, les interconnexions. Vous ne savez pas comment vous avez réagi à certaines choses ? La blockchain, ce sera la même chose. On pourra éventuellement remonter et avoir une chronologie. Mais ça, ce n'est pas quelque chose qu'on peut déjà faire dans l'IA. On pourra expliquer un certain nombre de choses, mais l'explicabilité, il faut en être conscient. C'est à dire que l'intelligence artificielle va être développée, et moins il sera possible de l'expliquer. C'est à dire qu'à partir du moment où l'intelligence artificielle aura des multi layer, des réseaux neuronaux qui vont faire des inférences phénoménales à la vitesse des neurones humains. Même le gars qui aura programmé l'algorithme de base sera incapable de vous dire comment il est passé de là à là, ce ne sera pas possible parce que la technologie, parce que le nombre de données qui vont être traitées, la vitesse à laquelle elles sont traitées font que plus on avance dans cette technologie, moins elle est explicable. Donc, là aussi l'explicabilité, ça fait partie de ces discours, la transparence, de ces discours qui sont des discours rassurants, qui répondent à des inquiétudes, mais qui répondent simplement sur le plan discursif, il n'y a pas de réponse. Il n'y a pas de réponse, je crois. Je regardais récemment. Je crois que c'est le monde, il y a quelqu'un qui a qui est allé dans le monde pour regarder les algorithmes de fonctionnement du monde, notamment de recommandations. Donc, il y a tout un article, je l'ai lu, je ne comprends rien. Et pourtant, c'est expliqué, mais assez hyper précis. Mais c'est méga technique. C'est explicable, mais explicable, explicable pour un scientifique qui a fait math sup maths spé et qui a fait dix ans d'études en physique quantique ou en mathématiques derrière. Mais pour le commun des mortels, il n'y a rien d'explicable. Je ne comprends pas comment fonctionnent les cookies. Moi, je dis oui quand on me demande est-ce que vous acceptez ou pas. Là aussi, il faut l'opérationnalité. Je pense que ça ne va pas s'améliorer avec la technologie qui avance. Si on arrive, on arrivera à ces systèmes qui sont autos conscients, qui s'auto déterminent. Il n'y aura pas de blockchains qui tiennent, il n'y aura pas de retour en arrière. Je vais essayer de comprendre comment ça s'est passé, pourquoi ça s'est passé, mais de la même manière que quand il y a un accident qui survient et que vous expliquez quelles sont les responsabilités des uns et des autres et qu'on essaye de refaire le fil de l'histoire dans un contexte humain, c'est quasiment impossible. Bien sûr qu'on fait des erreurs, mais ce sera pareil pour l'intelligence artificielle. Donc, je pense que le discours pour répondre aux questions oui, ça va aider à rassurer les gens et donc les gens seront peut-être un petit peu moins méfiant, mais ce n'est pas ça qui va faire que les gens sont méfiants. Ce qui fait que les gens sont moins méfiants, c'est le fait que ça devient quelque chose de banal, quelque chose qui, dans notre quotidien, on utilise l'intelligence artificielle sans arrêt, sans même s'en rendre compte, ça ne va qu'augmenter. Donc, c'est ça qui va faire que globalement, les choses vont devenir normales, banales. Et pour la question de ce que va devenir l'humain, ça dépend, il y a tout un tas de questions sur la définition qu'est-ce qu'un humain ? Il y a tout un tas de courants philosophiques qui veulent aller chez Descartes, vous avez un dualisme de l'esprit du corps chez les chrétiens, vous avez un triptyque entre l'âme, l'esprit et le corps humain. A partir de quel pourcentage de remplacement de son corps par des prothèses ? On est plus un être humain. Je ne sais pas. Est-ce que votre humanité est dans votre cœur ? Pour certaines personnes, est-ce qu'il y a dans votre cerveau auquel cas votre cerveau dans une machine, ça restera un humain. Est-ce que c'est tout ? Vos organes, votre cerveau, votre

cœur, vos os ? Là aussi, je ne sais pas ce que c'est. Je ne sais pas ce que c'est. Est-ce que c'est votre conscience ? Est-ce que c'est votre capacité à réfléchir ? Auquel cas si on est capables de dupliquer, on va créer un humain, mais l'humain est différent, un transhumain. Pour reprendre la philosophie transhumaniste. Définir l'humain, c'est hyper, hyper difficile. Donc, l'avenir de l'humain, ça dépend de ce que vous entendez par humain. Moi, j'aurais tendance à vous dire que si l'humain, ce sont des gens qui, comme vous comme moi, sont faits de chair et de sang, eh ben déjà, ça exclu tous les gens qui ont des prothèses qui auront une prothèse cardiaque ont des prothèses de membres qui vont avoir acquis et qui vont être assistées par des systèmes informatiques. Tous ces gens-là ne sont déjà plus humain à ce moment-là. Est-ce que finalement, cette technologie n'est pas la continuité du l'humain parce qu'on parle très souvent de l'intelligence artificielle mais il y a aussi cette question parallèle qui est celle de l'humain augmenté, c'est à dire, par exemple, ces gens, encore une fois, où ? Des militaires auxquels on construit des exosquelettes qui leur permettent d'être moins fatigué sur des longues distances, de porter des charges plus lourdes. Ces exosquelettes ne vont pas remplacer le squelette lui-même. On n'en sait rien. Si au départ il faut, il faut, il ne faut rien s'interdire. Parce que quand on regarde les travaux qui sont menés, que ce soit par l'Université de la singularité, que ce soit par la DARPA, que ce soit par l'Université polytechnique de Lausanne, quand on voit les travaux qui sont menés, tout est envisageable, tout est envisageable. BrainLoading, C'est l'idée de transférer vos capacités cognitives, vos connaissances dans un ordinateur. Donc, on va garder tout ce que vous êtes dans la tête. Imaginez, imaginez le truc, ça veut dire quoi ? Ça veut dire que mon moi serait dans un ordinateur. Mais qu'est-ce que ça veut dire que je ne suis plus un être humain, je ne suis plus à moi. C'est une question très philosophique, j'en conviens. Mais là aussi, ça veut dire qu'il faut dépasser ces schémas qu'on a autour de mots qui nous paraissent évidents, éthique, confiance, transparence, humain, intelligence. Tout ça, ce sont des mots qui, l'humain, en France, ce n'est pas l'humain, on peut discuter avec les aborigènes d'Australie pour voir discuter avec les Premières Nations au Canada, la place de l'humain dans la nature, le rôle de l'humain, la définition, l'ontologie de l'humain, ce n'est pas du tout la même que celle qu'on va trouver en France ou en Amérique. Ici, ce sont des perceptions complètement différentes. Je peux vous dire ce que je pense de l'humain. Mais ma vision de l'humain n'a aucun intérêt. Elle n'a aucune importance. Donc, là aussi, l'avenir de l'humain et de l'intelligence artificielle. C'est que c'est compliqué, c'est très, très compliqué. Après, ce qui est intéressant, c'est d'ouvrir un débat sur de vrais questionnements. C'est cette question de définition. Quand on dit intelligence artificielle pour la majorité des gens, le mot intelligence parle à tout le monde. Mais si je vous dis, prenez cinq minutes, définissez moi l'intelligence et que je demande à quelqu'un proche de vous faire une chose et je demande des gens, vous verrez que les définitions pour certaines seront très proches, seront très différentes. Mais malgré tout, on entend tous intelligence. Il y a tout un tas de travaux très intéressants en linguistique avec Ferdinand de Saussure, par exemple, sur le signifiant signifié qu'on va retrouver chez des psychologues comme Jacques Lacan, il y a ce signifiant, c'est à dire ce mot qu'on partage tous. Il y a aussi le signifié, c'est à dire ce que chacun d'entre nous met derrière ce mot, une perception et les idées qu'il y a derrière. Je pense qu'aujourd'hui, il y a des problèmes fondamentaux. Si vous voulez vraiment une ouverture en termes d'éthique, c'est cette question des mots, des mots ou de la définition des mots. Ce n'est pas parce qu'on utilise le mot intelligence qu'on a la même perception du mot intelligence. Évidemment, on n'aura pas la même définition du mot intelligence que va avoir un Chinois que va avoir un Saoudien, que va avoir un Malien que va avoir un Vénézuélien et un Russe. Donc là, Il faut aussi comprendre. Moi, je l'ai vu aussi sur cette

question des systèmes autonomes, on parlait de l'autonomie, qui est aussi un concept indéfinissable. Moi, je parle de l'autonomie, j'ai évidemment des références qui sont philosophiques. Quand on travaillait là-dessus aux Nations-Unies, j'avais des gens avec nous qui étaient là, qui étaient des ingénieurs et qui avaient une vision d'autonomie qui n'avait rien à voir avec la perception d'autonomie. Vous avez des politiques qui ne l'entendait pas le mot autonomie de la même manière qu'un ingénieur. En fait, on avait une diversité. On était incapable de se mettre d'accord sur l'autonomie. Moi, j'en parlais. On me disait ouais, c'est trop philosophique. Un ingénieur, c'est trop basique, Oui, mais c'est trop pragmatique. Donc, en fait, on est capable de se mettre d'accord. Ces mots fondamentaux. Et ça, c'est la deuxième. La deuxième ouverture que je recommande, c'est de dire que notre problème, c'est que on s'imagine que tout ça s'est donné. C'est comme ça. L'intelligence, autonomie, tout ça, c'est donné et qu'on n'a pas à se poser la question de comment les autres cultures le comprennent. Et moi, je pense que si moi, je pense que si un animiste, un animiste, vous allez en Asie, un animiste va avoir une relation à ce qu'est l'humain, la conscience qui n'a strictement rien à voir avec une vision d'un juif ou d'un musulman, ou d'un chrétien ou d'un hindouiste, c'est une vision qui est complètement différente. N'importe quel objet pour un d'animistes est doué d'une conscience, ce qui n'est pas le cas pour quelqu'un qui est très cartésien et qui est très européen. Donc, ces mots sont très importants, les mots sont très importants et aujourd'hui, il y a vraiment un problème de définition. Et dans tous travaux de standardisation que je fais, on n'est jamais d'accord sur les définitions, donc à un moment donné, on se met d'accord sur une parce qu'on n'a pas le choix, mais sur le fond, on n'est pas d'accord et ça nous renvoie à notre problématique fondamentale. C'est qu'on n'est pas assez multiculturel dans notre approche de l'éthique occidentale au centre est une vraie tyrannie, une tyrannie de l'Occident sur le reste du monde.

Meriyem : C'est très intéressant d'entendre ou maintenant de savoir quel pouvoir retirer des choses qui vont aller contre ce qui a été dit dans la mémoire et laisser une ouverture. Le but des futurs travaux, des temps ou autres résultats pour des étudiants handicapait niveau académique. Mais non, non, c'était vraiment intéressant de manger bien et j'ai bien aimé. J'ai appris la même chose et donc côté, tant mieux.

Emmanuel Goffi : Moi, ça fait plaisir que vous, vous n'hésitez pas. S'il y a des choses que vous voulez clarifier, clarifier quoi que ce sera toujours avec grand plaisir.

Emmanuel Goffi : Un grand merci. Un grand merci, merci.

Appendix W. Thematic Tree

Blockchain Definition	Ahmed Banafa : « Blockchain is a software. Blockchain is a combination of two things. Cryptography and human logic. Cryptography means you are encrypting the data. You are using the data in a way where only certain parties will see that one and the people who have certain private key can see that. Human logic is the consensus of if one of the nodes and we are talking about thousands of nodes, basically computers have the same copy of the information (...) If our government censorship, 20 of the computers in that country, we still have thousands outside that can hold their information» «Blockchain is not a database. A database has as an admin that control it and database is centralized. Database is we'll create, delete update, read those four functions. You created, you read, it updated and deleted. For blockchain, only to read and write. So two functions are not available in the blockchain that is available in the database. And database is very fast because it is a centralized system. (...) Data are in the store. You can store this data and it's sitting there and nobody can change it. That one is similar but other functions are different. » Daniel Yasri : « C'est un grand registre immense qui est décentralisé parmi les trois mots clés, sécurisé et plus ou moins transparent». « C'est faux de dire que ce n'est pas une database, ça peut être une base de données mais ce n'est pas un endroit de stockage de donnée. » Joan Van Loon : « Blockchain is mainly about all these different sets of information, all these blocks of information that are related with each other through processes. » « Blockchain is not one database. It's really a change of information blocks. And of course, everyone in this chain has their database with their own data. But part of it is that shared with the rest, and that is what makes the blockchain. » « Blockchain is a new way of storing blocks of digital information in an open ledger. That information blocks are linked sequentially in a chain across a business network and are secured by a form of cryptography so it cannot be corrupted or tampered nor can it ever be erased. It is completely transparent and everything can be tracked and traced with 100% accuracy. » Philippe Coucke : « Distributed ledger technology, manière en effet de distribuer et d'échanger des informations, des données entre des utilisateurs de confiance. » Julian Fifiield : « Blocks of cryptographically encrypted data chained together » «You chain it together cryptographically, so you got a tamperproof record that builds up over time. And then, of course it can be used in all sorts of different ways. » « It's not a traditional database, it's not a database. But you can store data on the blockchain and not change it but the perceived wisdom is that if you treat blockchain as a traditional database, you just dump everything into it, especially with these early iterations of blockchain and the way they've been constructed. They'll be too slow and that grind to a halt. They're very slow and in truth, good practice is that you only store on the blockchain the minimum that you need to establish the tamperproof record. » « immutable record across the value chain, and it will interact with and govern the rules around that. Once you set the rules, the machine will enforce the rules. So this will minimize or exclude anybody who's trying to break the rules or read the wrong data because the machine won't let you. You've got to follow the rules, only permitted people only permitted data can be written in. So that's a good point. » Hasan Kapasi : « It's a distributed ledger. The automation feature, the smart contracts. It's a cryptography event. And then last but not least, what we have over there is also the combination of all of those. » « you're bringing trust in the ecosystem using this technology. » Robert Miller : « It's a chain of blocks, you hash the data and put it in a block, include previous block's hash, and it's like a way of keeping a record of data that is time stamped

	over time. It is a way of gaining consensus between multiple parties on a single state and timestamping that. » Natalia Monteiro : « Blockchain is a platform that, very similar to the Internet, has brought opportunities that are clearly not tapped on at the moment. So I think it's actually Internet 4.0. And I see this is not implemented further because the industry is actually too busy trying to explain how it works. So when we first got an email, everybody was so excited. They are using it because it makes sense. Blockchain is a platform that allow actions that have been used in an unsecured way to be done now in a more secured, decentralized way without intermediates » Jonathan Passerat : « La blockchain, en fait, ça sert à avoir une chaîne de confiance de tous les événements qui se sont passés dans un système et que tout le monde s'accorde sur la valeur d'une certaine action. » « Quand tu fais du machine learning en réseau entre plusieurs sites qui collaborent pour le coup, mais qui ne sont pas forcément amis, qui peuvent être des compétiteurs, ils veulent avoir la preuve que ce qui s'est passé est vrai. Une des manières les plus simples d'utiliser la blockchain dans ce contexte, c'est de s'en servir pour comme un journal d'évènements irréfutables où tout ce qu'on fait sur les données dans un réseau, on va le loguer sur la blockchain et tout le monde va participer à ce réseau. Et du coup, on va augmenter la confiance en fait du processus d'entraînement du modèle de manière distribuée. » « Une base de données distribuée en laquelle on peut faire confiance. » Tim Richmond : Blockchain essentially is a protocol for interchanging transactions and it does this in a decentralized way. It's as distributed ledger. Every time a transaction happens, right, a block is added to the blockchain. And how it's distributed essentially is that this ledger is distributed across many nodes, computers around the world in a cryptographic way. It generates a hash. So it generates a code which encrypts that transaction and that's for the transaction to complete, it then requires decrypting. Blockchain is a decentralized way in which transactions can happen in a way which requires no centralized body. » Hubert Ridolphi : « Pour moi la blockchain c'est un outil. Ce n'est pas une fin en soi. C'est un outil qui permet de techniquement montrer le trust des utilisateurs et des contributeurs à un système. »
Blockchain issue	Ahmed Banafa : « You get to start the blockchain and that takes a lot of power, a lot of time, a lot of graphical processing units. » « Number one is scalability because of the nature of the blockchain that everybody has to agree to. So if you have a thousand computers, you have to wait for everybody to agree on this. So you have scalability. You can't scale it up. And also you have the processing power because they have to solve that mathematical problem and the processing time. And give you a simple example about what I mean by that. For Visa to process your credit card when you go to any store, the system there, runs 24 000 transactions per second so you do not feel it. Bitcoin, the biggest blockchain network, only runs on 7 transactions per second, so you can see 24 000 and 7 transactions per second is a big difference. The speed is problem. The processing power is a problem. And also you know, the whole thing about, the scalability, add to this is blockchain is a victim of bad reputation because it's associated with cryptocurrency and cryptocurrency is not a good name in many countries. They associate that one with criminal activities, with ransomware, with so many of the bad things or the bitcoin, which goes up and down and crashes and some point people lost their money. And the other thing is the regulation, the regulation itself. Because we do not have enough regulation. Maybe in Europe they are more advanced than United States when it comes to the cryptocurrency. But the United States is very tough for the regulation. It's not approved yet. At the top of that, when you're talking about the people, we do not have enough skilled people who know what is blockchain. When I teach the blockchain, I have a full class because everybody would like to know what is that. And, you know, you go outside, you look at the universities, how many university or in the world actually teaching a whole program, of blockchain. It took me a month to convince Stanford and San Jose State, just to let me

teach the class. That was in 2018 before we have all this big noise. That is going to be the future, trust me, and we do not have enough people to go and teach that because they have the skills out of that process. So those are the main challenges facing the blockchain. »

« No standardization is also another problem and for good reasons, because blockchain industry is hundreds of billions of dollars' industry and nobody wants to give it away. Everybody wants to have control and have the whole market for themselves. » « That's what it means. We have a problem with the blockchain, standardization because you can go to Amazon and get your own blockchain, you can go to IBM and have your own blockchain, you can go to Microsoft, but you cannot mix them. »

« The fifty-one percent attack is one of the problem that is facing the blockchain. But it's very difficult to do (...). It is so difficult that it's not worth it. (...) So it makes it so difficult for people to do that. In order for you to reach the 51% attack, you have to have so much computing power. You have to have so much time that the money you're going to spend on this is more than the benefit from stealing this data. So that's number one. Number two is there are safeguards. For example, there are some of the systems that I'm talking about, the private blockchain in this case, if they see that third of the nodes, somebody changed the information, they shut down the whole system, they just shut down the whole system. They just stop everything before they can get the fifty-one percent. »

Daniel Yasri : « Personne n'a encore percé dans la blockchain médicale. Il y a beaucoup de blockchains médicales qui essaient. Il y en a beaucoup mais c'est juste que personne n'arrive à s'imposer sur le marché parce que les gens sont frileux, parce qu'il y a des limites à la technologie » « Le problème c'est que si demain la Belgique fait sa blockchain, ça ne va pas être la même. Et si on n'a pas cette interopérabilité, on va avoir les mêmes problèmes sur l'exécution des contrats, des smart contracts. Il y a un problème de standard en blockchain, chacun fait ce qu'il veut. Consommation énergétique également, qui est réglé avec le proof-of-stake, proof-of-authority, etc. La taille du réseau blockchain. Il faut quand même plusieurs nœuds pour arriver à accomplir cette vision de décentralisation. Tu ne peux pas dire j'ai 3 serveurs je fais une blockchain. » « La taille du réseau c'est vraiment quelque chose qui peut freiner la blockchain. Il faut beaucoup de nœuds. Pour éviter aussi les 51% attacks. La vitesse et efficacité, la blockchain ça peut être très lent Il faut que ça aille vite. Gestion de l'erreur. Il faut faire attention. Normalement il n'y a pas d'erreur en blockchain mais ça permet d'éviter ça. Mais il ne faudrait pas qu'il y a une erreur dans un bloc. (...) Ce n'est pas arrivé, mais si ça arrive, ce serait dommage. Il y aussi selon moi, le défi légal. Est-ce qu'on peut mettre des données patients sur blockchain. J'ai écrit aussi tout un article dessus, tu verras, le GDPR, les données patients, les données des gens, est-ce-qu'on a le droit de les mettre sur la blockchain ? La blockchain c'est immuable, du coup comment les gens peuvent retirer leurs informations. Tu as le droit à l'oubli. » « Le coût, c'est aussi un problème. Ça coûte cher de développer une blockchain. Il faut des ressources technologiques et financières qui ne sont pas comme les solutions traditionnelles. Mais après, quand il y aura des acteurs comme Microsoft, Amazon, IBM qui vont s'y mettre, et que ça va devenir accessible, il n'y aura pas de soucis. »

Natalia Monteiro : « the major one is we still need to rely on the cloud solution on the background because the blockchain is not meant to store data so there will be a lot of clouds and we have national governance where the servers need to be in a certain country, the cloud needs to be in certain country. So this is all valid. We have different regulations and so on. So I do not think it's a drawback per se, but I think it's a risk. So what happens is that we need cloud security because we need to protect this information. Again, on another point, you know, that's something that I have discussed for instance, is that a lot of countries, they're trying to do this electronic health records and centralize everything. And there are suffering. That's not happening because people are afraid. What if someone else gets a hold of my data? And what I think it's also that blockchain provides the solution in the sense that we do not need to collect the data together. So an example

is, imagine that someone has a heart condition and has a mental condition. So perhaps this person does not want the employer to find out that there is a mental condition, find out that there is a mental condition, depression. I do not know exactly, but these two data points, they do not need to be in the same health record. So the mental hospital, the mental institute, can collect the data of that patient and keep it in the cloud at the same time, the heart condition is kept on that cloud. And when he shares, he just shares the minimum required information. I think that this integration of decentralized silos could also be a great use for it. So, again, I think I've just mentioned a drawback that can be also a positive use. But I think the drawback is the reliance on data repository. So those need to be really, really secure and allow the users to feel secure as well, because that will help adoption and also sustainability of the system and over a long period of time. »

« I'm also a member of the Ethics Committee creating standards for blockchain. It's called IEEE. So there is a blockchain committee where we discuss in pharma what is ethically acceptable from the blockchain point of view. And those ethical committees were not meant to be bypassed. »

Jonathan Passerat : « A l'heure actuelle, il y a encore des problèmes de scalabilité, le passage à l'échelle en termes de nombre de transactions qu'on peut faire tourner. On a aussi pas mal la multiplication des réseaux de blockchain. Je ne sais pas si c'est bien qu'on ait beaucoup de blockchains. Je pense ce qui va arriver à terme, j'imagine qu'en gros, il va y avoir une blockchain publique, qui va émerger, qui va être dominante. La manière dont je le vois fonctionner à terme, c'est que tous ces sous réseaux, toutes ces sous blockchains, elles auront toutes la capacité de se raccrocher à la blockchain principale. Et je pense qu'il y aura une sorte de backbone de l'internet par une blockchain publique auquel tout le monde aura accès, qui sera cette source de confiance entre tous les protocoles qu'on pourra développer et qui eux-mêmes pourront développer leur propre sous chaîne, leur propre sous réseau. »

Tim Richmond : « So actually the miner in some circumstances there are blockchains which are minerless and in fact the process of having a minor is what slows down the blockchain. Blockchain is very slow. It's slow for many reasons, slow because it requires a wait for compute time, a miner to pick up the transaction. Slow because the computational power requires to process that and slow because of the volume of transactions at any one time can be more than the computational power available. but there are a number of solutions which look to get around this, such as hash graph, which is a way in which you can manage a transaction without Miners effectively » « The disadvantage is the moment you remove the miners, you always have to reduce the number of possible nodes and therefore you're increasing the amount of centralization within the system. So it's like a balance. What's going to happen in the future is we're going to have quantum computation. So quantum computing and also quantum cryptography. » « So the way in which blockchain works now is going to be forced to change, along with all of the computational based security systems. So Quantum cryptography, on the other hand, is a way in which you are able to send data using fundamental laws of physics to encrypt data, so it uses basically something called entanglement. »

Hubert Ridolphi : « L'implémentation n'est pas un challenge. C'est vraiment facile d'implémenter la blockchain. Ça peut sembler difficile pour une personne « non technique » mais la blockchain est vraiment un outils et je vois des gens développer la solution blockchain pendant une pause-café, la codant et s'assurant qu'elle fonctionne. Concernant l'aspect technique, ce n'est pas compliqué. Mais l'application est compliquée. Tu dois trouver la bonne application ou la blockchain va amener quelque chose. »

Blockchain Benefits

Ahmed Banafa : « The number one is trust. You know, if the Internet is about connectivity, when are you talking about what we are doing now with the Internet. Blockchain is about trust and that trust is actually among people. They do not know each other. I mean, you could be a node on the blockchain and I never heard about you and this is the beauty of that one. Number two, it is immutable, it means you cannot change it, so you cannot change it once you have it. It's a software. You enter that information. There's no way for change because the internal structure of the blockchain is you have a block, you have the information this is going to be encrypted and added to the next block. And so if I change this one, everything up to this one will be corrupted because you cannot change one of them. The only way to change whatever inside the blockchain is to have something called soft fork or hard fork. So soft work is a simple thing, like an upgrade. You change the size of the block and hard work is something wrong. If the information is wrong and you want to change it, you just start again, you stop this process, you start again from a different one. That's called the hard work. So it is immutable, it is distributed. There's no centre, you know, computer or set of computer people can attack and shut it down. It is all over the place. So if we have a thousand computers, have the information, if we shut down at two hundred, we still have eight hundred. So that's one important thing. Transparency is there. I showed my students the transactions. You can see just the encryption are from two and how much they sent, but you do not know who sent it and who receive it. You just verify that the transaction is correct. So that transparency is there. It gives people some kind of assurance that this transaction is the same as this. So we can approve it. It's going to go ahead with the process. So this is some of the benefit of the blockchain. It's going to apply to everything, not just AI. It can apply to a supply chain, because if you are sending any kind of food like produce or any kind of fruits or vegetables and, it stops at this place, it stops at this place and the weight is this and the temperature in this place, if somebody's recording this by hand, they can change it. But if it's recorded on the blockchain and I can access it from here looking at it, I can see that this is why we lost that shipment, because the temperature is really high and it spoiled and it's rotting. But if somebody changes it or changes the weight and see, the weight is this and it's basically it is more or less. In the system and this is all automated, you scan it and you get it, it's not like you add it by yourself so you can trust it, you can trust that information. » « Your information, your identity, basically, you're defining your name, your driver license, your birth place, birth date, and all this information will be in a digital form. That's what blockchain deal with data for. And this one can be encrypted in a way where the smart contract will give somebody's access. If you release that one, you say you have a list of agencies. The police can access it. The government can access it. My parents got access to things like this one. They can access that when they can just show it to them. Other than this other people, there will be a condition saying "they send a request" to me. They say, can we get this information? You give us permission to do that. Once it is written in that software, which is a form, you fill it and it is online, you fill it and it is part of it, then your account will have complete account control on this. You know, if you have Facebook or if you have any of the social media, you go to privacy, you're going to see those options, right. You turn them on and off. This is exactly what you are going to do with this. And you can have some block addresses. You can add people you can block or you can unblock certain people. »

Daniel Yasri: "Sécuriser les données de santé. Mais mon Dieu, qu'est-ce que ça serait le pied si on avait les données de santé sur blockchain (...) tu sais que toutes nos données patientes sont centralisées dans le même serveur. C'est à dire que si un jour, il y a quelqu'un qui s'amuse à le pirater, Il a accès à toutes les données et peut tout faire exploser. Et qu'on me dit oui en ce moment, il y a un dysfonctionnement parce que le truc est centralisé, il est centralisé. Il faut arrêter de centraliser les données importantes. Ça n'a pas de sens. Ça veut dire avoir un seul point d'attaque pour n'importe quoi (...) pourquoi ce registre il ne serait pas haché? Justement, ou encodé via la blockchain. Deuxièmement, pour moi, ça permet une interopérabilité des systèmes. » « Je ne sais pas

comment ça marche chez vous en Belgique, mais moi, si je prends mon dossier médical et que je vais juste chez le médecin, chez mon médecin et que je vais chez le médecin qui est deux villes plus loin, et bien, je lui dis bien vous n'avez qu'à prendre mon dossier de là-bas, c'est pas possible, je ne sais pas comment ça se passe en Belgique mais si tu veux avoir un médecin que tu n'as jamais vu, il n'a pas ton dossier médical. Mets-moi ça, dans une clé privée strictement privée, c'est un hash là, tu donnes ça à ton médecin il la rentre et il voit tout tes trucs, quoi » « L'essai clinique ça rentre dans la blockchain parce que on collecte des données de recherche, donc collecte de données dit blockchain. Parce qu'on veut certifier la donnée. Parce qu'on veut être sûr qu'elle soit timestampée, on veut être sûr que ce soit la bonne donnée. Tu ne peux pas te permettre dans un essai clinique de dire ce n'est pas la bonne, je ne suis pas sûr que ce soit le bon patient, je suis pas sûr que j'ai donné tel médicament. Ça respecte le protocole, du coup, tu peux être sûr d'une traçabilité et ça permet d'inclure plus facilement des nouveaux patients puisqu'ils pourraient tout simplement, grâce à leur dossier médical, leur clé, rentrer dans l'essai. » « Avantages c'est moins de paperasse, moins de soucis de stockage » « ça permettrait d'avoir une plus grande qualité de soins. Vu que si tu as des meilleures informations, qui sont à jour et qui sont compréhensible, ben tu as une meilleure qualité de soins tout simplement. Meilleure efficacité et productivité également. Et pour moi, ça met le patient au centre, comme c'est toi qui à la clé privée, c'est toi qui as ton dossier en main donc tu deviens beaucoup plus acteur de ta santé. Les patients ne savent pas ce qu'ils ont eu, pourquoi ils l'ont eu. C'est vraiment compliqué car ils ne sont pas du tout au centre. Il n'y a pas de empowerment. Ils font confiance à l'hôpital. S'ils vont au même hôpital depuis 10ans, ils peuvent avoir un bon dossier. La personne déménage, c'est foutu. »

Joan Van Loon : « So companies working together and having to share information from one to the other, making sure that this spot you mentioned is in a secure way so that nobody could change the data or tamper with the data and that it's open to everyone in the network. And that is why it is very relevant in health care from that perspective, because in health care, you have the labs, you have the hospitals, you have the patient, you have the pharmaceutical industry, you have the regulators, the payers, so the insurance companies, the pharmacies, the distributors. So there are a lot of players who all have different sets of information. »

« A blockchain helps to build trust » «Immutable, auditable records, because that is basically what blockchain is about. So it cannot be changed. It's auditable. So you can always control afterwards which data have been entered. Which information has been entered, transaction dependent or interrelated. » « It reduces the risk that's why blockchain exists because it's auditable and everything is visible and everything is collected. You can build in the security of data tampering. » « Governance is maintained through the fact that it is an open network. So everybody who is part of the network with permission. So you have to be permitted to be part of the network to see some of the transactions, to see some of the data. And then it's basically self-regulating. »

Philippe Coucke : « Ca devrait améliorer les échanges de données, augmenter la sécurité. »

Julian Fifield : « No one's ever hacked the blockchain, but they've hacked some of the exchanges and distribution points and stolen things. But you can't hack blockchain today anyway. So there are security issues. But remember, in a private permission chain, the rules, who has access, who can see, who can read, who can download are governed by the machine. And if you write the rules properly, they are a scale more secure than traditional systems and databases and people. I would argue that the security issues are still there, of course. I mean, all these things are held in the cloud. But one of the things is there's no single point of failure with the blockchain because it's distributed across all of the actors and the stakeholders. So if you were a node in the blockchain and we lost you and we lost your data, the machine is still there. It's almost impossible to get rid of the blockchain once it's built because it's all over distributed and you decide how many distribution points there are, how many nodes there are in the system. So personally, I would argue if

you look at the risks people are running now. Security risk that people are running now with their data, they're running very high risk. Dirty data, hacking ability for internal stakeholders to compromise the data, ability to download the data, and leak it. All of those things could be massively improved if a machine was looking after it using tamper proof methods. So I think it's a move in security. I'm not saying it's risk free. Nothing is risk free, but it's gotten better than what we've got at the moment. The banking system and the movement of money globally, it's riddled with fraud. Riddled with fraud, hundreds of billions of pounds of fraud. So we're running really risky systems now. But that's really scary for the banks. You've got to understand risk in context, big security risk, lots of risk now. Lots of problems. Lots of issues, fraud. Blockchain can eliminate a lot of that. »

Bill Inman : «Blockchain is the technology of trust because of immutability, and it's a great opportunity to store that in an immutable record. » « Explainability, transparency and explain any bias or showing bias. »

Julian Fifield : « Scalability is a problem at the moment. Transaction speeds and the ability to press the stakes are very high speed and it is increasingly available. So you kind of got that. The ability to securely reference data that's held off chain can be a way around it. But the point is, blockchain isn't trying to duplicate and just make a better database. It's not trying to do that. It's trying to do something else. So effectively, as I said, blockchain doesn't exist on its own. It normally works in an ecosystem of data and people. It exists as an ecosystem. It's only a problem if you think the job is to create a new kind of database. It's not, it's a new kind of truth. It's a new kind of authenticity. It's a new kind of proof and a new kind of trust. That's what blockchain is about. But the blockchain will enforce the rules for the database. So blockchain is the supervisor, the governing agent, and will prevent abuse, as it were, by the traditional database. It's a governing agent. It's a governing framework. I would imagine there will be massive improvements in data and block size anyway, and that's just a question of time. I'm sure that will improve a lot. But we're only a few short, short years into use cases here. » « It is like in any other technology. There are security risks, availability risks, hacking risks and the like, although no one has ever hacked blockchain »

Hasen Kapasi : « In terms of time, you're really chasing on it. You're automatizing the major processes in terms of advantageous. Another one, what you can do is removing the intermediaries. You're removing people and all kind of key bottlenecks in between. So that is one of the major benefits. I think one of the major benefit by people on using blockchain in the industry as a single source of truth. So blockchain is a piece of technology, but it's connecting multiple companies, which is not possible with any of the technologies. And I think that is one of the key advantages. What we chase in the industry at the moment and which is another advantage is immutability. Nobody can change anything. »

Robert Miller : « Trust and a neutral party between multiple different entities. »

Natalia Monteiro : « The basics of blockchain is that it increases traceability, increases trust, increases decentralization of data, and this again increases trust. » «When we look at the clinical trials or the health care in general, the benefit of the blockchain is trust. And why do we need trust? Because there is mistrust in the system and patients do not trust pharmaceuticals because there is an interest in the pharmaceuticals of sell more drugs. Government do not trust pharmaceuticals because they are paying for those drugs or for those treatments. So everybody has their own interest in this. Once you use a decentralized system where everybody both feeds and can get information out of it, that's when you are going to get the most benefit out of it. So I believe the blockchain is actually shaking a lot the traditional systems, and that's why the implementation is taking a little bit longer. » « It provides a greater transparency. In my example, for instance, the patient, when he is a part of a study, he knows exactly which data he is sharing thanks to the smart contract. So instead of taking another lab exam, he says, no, I've already taken this last week with my GP and the data is in my electronic health records. All I need to do is to allow you to see my results. So this is not even simpler, but it also saves money for the

clinical trial. So he allows it via a smart contract. So now a third party is allowed to see, it provides greater transparency. Right. For the patient, he knows exactly who owns the data. He owns the data, but he knows exactly who has access to the data because he authorizes the person. This is a greater transparency but not everybody is a big fan of it. Because the data is used with different uses and not every country has higher standards, so that's one of the hindering parts, not that I find it's hindering, but I just think that that's one of the reasons. Another one is, for instance, speed of transactions. This makes everything much faster and traceable. What would be the need for auditors? If everything is actually locked in, of course, auditors and auditing companies do not have an interest for this, they will have to redefine themselves. And with models in A.I., for instance, you can just see if something hasn't been done properly. An example I can give you again, from the clinical trials I've looked at, it's the protocol. Once you start to study, you need to prove that when you were researching a certain drug, you were researching for X use. If in the middle of your study you realize, well, actually this drug has the Y side effect and this Y side effect is a quite positive one. Why do not we try to market this drug for Y instead of X? And that's what the protocol at the beginning of the study is meant for. It's actually to assure authorities that you are not changing your study as it pleases the pharmaceutical company. So if that would be the case, you would have to go back and say, now we need another study to prove that Y is a good application for it. And then once you've got the drug, what happened is that you need governments to check the protocol and you need auditing firms checking this protocol, if that would be on blockchain, you can imagine the amount of, less administration that is necessary. Also for those agencies, FDA will have much less trouble because all they need to do is to send a smart contract and the FDA sees our files as they are found through the smart contract. You can check everything when the first call, when the first protocol adjustment has been sent and so on. So actually, the speed and efficiency is incredible. But you still see parties involved that have very little interest for this to be in place. »

Jonathan Passerat : « Ce côté non modifiable, non censurable. Finalement, c'est une infrastructure plus qu'autre chose. C'est doit être un service, presque un, un service public comme internet qui permet à tout le monde d'avoir d'avoir une base sur laquelle se reposer, sur laquelle il sait qu'il pourra toujours accéder, que personne ne pourra l'empêcher d'accéder à ce réseau.

Tim Richmond: « One of the frustrations that data scientists have in general is bias in data. I'm not talking necessarily about human bias, although that is obviously a factor. I'm talking more along the lines of systemic bias. So what I mean by that is that by building the model yourself, you are not by nature, you're already placing restrictions on the model. And so therefore there is always a natural bias. So how do we get around this? And it's a major problem. Blockchain and decentralization seems to be the key to this because it has to seemingly oxymoronic, it is a good word. It has two seemingly different properties which actually work together really well. And the first thing is that blockchain is immutable. So it's permanent and it's traceable. So you can trace every piece of data that flies around there. But it is also anonymous in the sense that you can anonymize data. In a way which means that it's private, to a degree, in terms of it's not directly linked to you. So why is this important for health care? Well, it's super important for health care because to create systems that are able to assist AI systems, that are able to assist medicine, we need data. And the only way to get that data is from the ground, from the people. And medical data is obviously one of the most closely guarded personal data that you produce in your life. » « Trust is a major factor. But if you have a blockchain based system, a decentralized system where your data is anonymized effectively. You're able to add value to the overall data set and get over the whole centralized control system. » « Singularity has a spinoff company called Regiu is an app, which is close to launch. And what it does is it tokenizes a monetizes your personal data. It takes your sensory data. And then feed that into an A.I. model and that A.I. model feeds back to you, your, it looks like your pre disease by predictive modeling » « So it's kind of like a win win,

	really, because obviously they're getting the benefit of A.I. assisted health care, but also they're being rewarded for adding that data into increasing the quality of the model. » « Blockchain, actually, cryptography in general and the way in which humans use crypto. It's a very exciting thing. But actually, if you look at the way in which blockchains are designed, they're really designed for communication between machines so that the major benefit of decentralization within the blockchain and block chain style transactions is, is that it facilitates an environment where machines can transact between themselves » Hubert Ridolphi : « Très facile à implémenter. Puis également, tu ne dois pas partager l'information. La blockchain ne sert pas à partager les données mais à prouver que les données sont partagées. C'est d'un autre niveau pour moi. Tu ne dois pas utiliser la blockchain pour stocker des données, tu utilises la blockchain pour partager des données. La blockchain ne sait rien par rapport à vos données. Tu garanties le partage de données sans avoir les données au sein de la blockchain » « L'audit des données d'études cliniques pour voir que ça n'a pas été tempered, ça oui. Oui, la blockchain est là pour vérifier que ces données n'ont pas été modifiées. »
AI & blockchain together in general	Ahmed Banafa : « The both technologies are really a match. They are the same level. They are not one is weak, the other strong, one strong because each one of them is like a superhero, one of them has certain powers, the other one has certain powers. Joan Van Loon : « Well, I think they both have a purpose and a business case. And like we talked, there is a purpose and a business case for putting both together, but both could also perfectly exist, walk next to the other, serving their own purpose. So so, for instance, if you want to solve the issue of auditability, OK, then you can do that with blockchain and you do not necessarily need AI. If you really want to go for finding new cures, for finding new diagnostics, for finding new treatments for diseases, then AI can help you there without needing blockchain. So again, both can and strengthen each other through the auditability process and so on and so forth to managing the process and the governance. But they are not needed to have positive effects from blockchain or for AI so they can have the positive effect without going together. » Hasen Kapasi : « Etchically, so as I mentioned, how we use that data. So it needs transparency. And that is how you can connect with the blockchain, because if you're just here with AI, you need to have some trust on data you are sharing. » Philippe Coucke : « Si vous avez lu mon livre, j'admets que dans l'écosystème que je prône qui est basé sur du big data, de l'intelligence artificielle, il faut mettre en place un système qui permette un échange sécurisé des données et que la, la blockchain apporte des solutions. » « Mais je suis aussi conscient que je ne veux pas que mon dossier médical figure sur la première page de la Meuse. Qu'il soit accessible dans un contexte d'analyse de big data. Mais il faut bien entendu mettre en place des garde fous et des garde fous peuvent être mis en place par une technologie de type blockchain où on contrôle qui amène l'information et qui l'utilise. » Julian Fifield : « Blockchain is one of the few, if not the only potential mechanism for capturing truthful information. Conveying it across the supply chain or the value chain and then being able to perform interesting things with it, like artificial intelligence and machine learning on top of it. » « And in health care, of course, as you know, the use cases for blockchain and AI and machine learning are immense. I mean, huge transformational » « Counterfeiting of products and drugs. Huge problem that could be eliminated or pushed to the edge with blockchain and then artificial intelligence can start on the beauty of this is you can start to monitor transactions and supply chains in real time and the machine will run really fast, faster than anything else you can do » « But, people haven't quite got their heads around yet. » « And then the machine will enforce the collection of that data

so that you can then start to run artificial intelligence machine learning algorithms on top of it, because then everybody can trust it »

Bill Inman : « Well, data, for sure. As being an immutable record of data from an enterprise perspective, it allows us to confidently leverage A.I. and the data sources to make sure that there's less bias, it's more accurate and so forth and more easily connected. But how we are using Blockchain with A.I. at Singularity is that anybody in the world after proper approval can post their AI agent into the singularityNet platform. And it's tokenized so people actually get paid through the AGI token and by usage. So the more their AI agents that they post are used, the more they get paid with tokens. So this decentralized model, crosses borders and crosses company size. Individuals can post their agent enterprises, can post a free agent. So being decentralized and using the token to incentivize people allows us to do something entirely different with A.I. It can help to bring disparate AIs together into one platform that can be compounded on top of each other to create new solutions. » « Well, the alternative to decentralized data is big tech A.I., Google, Deep Mind, Tencent, Alibaba, Amazon Web Services and of course, there is basically the layer on top of those enterprise solutions. And you're limited by the creativity and the architecture and the security of the centralized platform. So decentralized circumvents all of those challenges, the talent needed to create AI on the platform, the lack of ingenuity, being centralized or centralized governance,... And also there's the potential for these enterprises to do either unwillingly or unknowingly or knowingly nefarious things with the data and with the information. By having it decentralized, there's not one enterprise that's in control. It disperses the control of who's operating in the AI into individual segments.. »

Daniel Yasri : « Je pense que la blockchain peut absolument, absolument, aider l'IA en termes de big data. La triangulaire big data – blockchain – AI c'est vraiment ce qui fait que la blockchain et l'AI peuvent travailler ensemble et sont une technologie d'avenir »

Robert Miller: « No single party controls, and that's useful in a number of different contexts. For AI in particular, it might help orchestrate the training of an AI, trigger certain actions at certain times, maybe decide parameters in which an AI can output a prediction. Maybe you need to pay or record an audit log of actions. And I think this ability to orchestrate things in a way that no single party controls is very useful generally and specifically within AI. » « there's some conversations going on with pharma companies of using a blockchain to provide like a trusted base ensuring no one is tampering data, which, then if you're using that with AI it can help you ensure that the AI predictions are correct and it has integrity because the data that it's trained on, has integrity. » « I was just reading this article on blockchain based machinery marketplaces. But Fred's idea is basically to use blockchain as a way to incentivize people to provide data to machine Learning algorithm and then also as a way to create marketplaces for these algorithms. » « I think the real potential for blockchain and A.I. lies in its ability to create technology services that have a better relationship with users and are organized in a different way, where maybe users have more choice of the algorithms that they're using and even have ownership over their algorithm, people are getting paid for their data, maybe there's more open marketplaces. And people's privacy is more respected, too. This idea of incentivizing people, I think it's very compelling one to me. And that's where my core interest lies in the future. So if they didn't get across, I wanted to stick that in it before the end. »

Natalia Monteiro : « There is in the pharmaceutical I was working, we were looking at two models where you can actually apply AI into a blockchain where you do not need to reveal the data, so the model goes inside, checks for the result and comes out with the answer. In the example I gave you about, if we would turn the number three, four participants in that example, for instance, an AI model, could go in, could run inside the blockchain, you could run inside the clouds, behind the multiple clouds behind this blockchain and turn now to the number three. »

	Jonathan Passerat : « Concensys health, spinoff de consensys juste dédié sur la santé, dont le but est d'exploiter au maximum ces techniques de calculs confidentiels calculs privés, mais en lien avec la blockchain. L'idée, c'est que ces techniques de calcul privés, on les utilise principalement pour faire du machine learning. Du coup, c'est là, c'est là d'où vient le lien, entre autres tout ce que je fais sur le côté machine learning, calcul privé. » » Je la vois vraiment, pas pour le très court terme, mais je le vois si on arrive à mettre en place des choses assez complexes, comme je l'ai dit en fait, si on arrive à mettre en place de la gouvernance, ça, j'y crois. Mais pas forcément au niveau que de la donnée. En fait, je pense qu'on va arriver à mettre en place de la gouvernance de modèle d'IA aussi. De la monétisation, peut être. Mais ça, ça ne passera pas que par la blockchain. Pour moi, c'est la combinaison de la blockchain, oui, mais c'est peut être 20% de blockchain et 80% de cryptographie » Tim Richmond : « So what you can do is you can connect those two together using an API, right. So the two connect and then you code your own program. Right. So this is already something which we've done with a music app. So we've leveraged an application from the platform, incorporated it into an application. This application strips audio strips of voice from a song. Right. So the coder basically creates an application and then draws in these different AI by API and then that's how they interconnect. So it isn't a case, like I say, we haven't got to this abstract reasoning where we can say, I would like this because ontology of A.I. means that they basically would have to understand what they do, in relation to what was requested and understand the same for other A.I. algorithms and then decide which one they want to connect with, that's a separate thing which doesn't exist yet. But at the moment, so if I wanted to create this algorithm that monitors a baby. Right. So I could create, I do not know, I could create a camera webcam or a baby monitor, which leverages the blockchain to bring in services from these different algorithms to deliver the service that I want. Right. That's how that's how it works at the moment. So you bringing in. So that's where the block chain really has value. It's transactional, it's I mean, the blockchain is the protocol of data, right? Blockchain is the protocol, the transactions. So, it allows you to make purchases directly from the connections, directly from the AI itself, the data that's coming to and from it, it is probably being transmitted over IP. Right. So it's not it's not specifically necessarily blockchain, but the smart contracts, the blockchain obviously runs by having like on Ethereum, for example, the smart contract so you can you can create your own rules set for these transactions. so you can do some quite clever things actually » « At the moment, blockchain and decentralization gives us the ability to bring in different AI from different places and all interconnected. So hopefully the learning that it made in terms of decision making can be translated to autonomous cars, for example. So although you do not think they have any relation. There's some level of decision making learning that's happened in this algorithm that could be valuable to an AI which is driving a car. Maybe it needs to strategize about the position that is on the road. And so blockchain gives the ability for these different models to connect to each other »
AI Definition	Ahmed Banafa : « There is a machine learning and deep learning. Those are the three terms you have to know and they are interrelated. « It is a small circle, which is deep learning, a bigger circle, which is machine learning and the bigger circle, which is AI. » « Think about AI in this part. Machine learning means you are developing a program. We call it a model. That model will recognize certain inner features or certain activities, finding some kind of a pattern. That's what they are finding a pattern, to do that. So if I have a picture of a hundred people, faces of 100 people, and then I wrote a program that will recognize the people who are smiling in those pictures, and then I scan those pictures and the computer will say, OK, five of them there are pictures of people are smiling. Why? Because you can define the smile with, you know, how far is the lips and the eyes, and all these. There are certain features. So out of the hundred, the computer found five. This is called machine learning. This is finding people smiling. It's got a pattern. Deep learning is why they're smiling. This is a real smile. This is a smile, is this is a fake smile. If this is a

	smile that somebody said it because there's a gun at their head sometimes. So that's deep learning. When you mix this with this machine learning and deep learning, you get artificial intelligence. So if you have more of deep learning, than machine learning, then you're going to have more in-depth artificial intelligence that deals with emotions, deals with what's going on with the with a human being as human. If you have more machine learning programs, then you are dealing with patterns, insights like a business. » Daniel Yasri : « Il y a plusieurs types d'IA, Deep learning, Machine learning, ou tout simplement l'IA sur ses plus simples appareils (..) , c'est plus le ML qui est utiliser » Joan Van Loon : « AI is the technology that can help you find new knowledge in information and data, and this means this goes a step further than what we call traditional analytics, because traditional analytics is about data looking into the data and trying to find information from the data or results from the data. AI go one step further. It creates new information, new ideas. So that's the main thing. And if you look at A.I. from the perspective of a human brain, the ultimate goal has always been to replicate the human brain into AI technology. » Hasen Kapasi : « Pharma has a lot of data and machine learning is really making sense of the data which human cannot read, comparing some out of the box data sets. » Robert Miller : series of algorithms that are used to make useful predictions about data Natalia Monteiro : A.I. is actually a way of making the most of the data set to have. So there are models of optimising the utilization of all of the data and the process that we have. Jonathan Passerat : capacité d'un système à agir de manière autonome sur soit un problème unique, soit un ensemble de problèmes, soit complètement raisonné de manière autonome dans un environnement total comme un humain. Du coup, ça serait plutôt ce qu'on appelle AGI, Artificial general intelligence.
AI issues	Ahmed Banafa : « The biggest problem of artificial intelligence is the concept of bad data. Eighty percent of the time of the data scientist who the people are really running the artificial intelligence programs and machine learning, the 80 percent of their time they spend in cleaning data, which means they look at the data, which is just a petition, or sometimes you have an outlier. You know, temperature is twenty-five, twenty five and suddenly it is two hundred. That makes no sense. You know, people are going to die if it's 200. So you start cleaning the data and the other 20 percent of their time is spent on processing the data. So that is one of the challenges they are facing when it comes to artificial intelligence and the dealing with artificial intelligence, having a clean data to get and process that, and also having this process of continuous data that the data is updated and updated and updated because you do not have a model about something which is old. » « We do not have enough people who really can deal with artificial intelligence. We need data scientists and data scientists is not just a programmer. Data scientist is a person who actually knows the number one programming, number two, math, number three, psychology. So this person has to know the psychology because this is going to have to find the pattern in that one so we do not have enough people. That's why they pay them a lot of money here in the United States. They pay them tons of money or because we do not have enough of this kind of expertise, that's another challenge you have. The other thing, which is, you know, I have to say it is one of the problems we are facing nowadays is the bias. » « By the end of the day, if I write that program, I will have my own beliefs when I write that program, I will have my own parameters of that program. So this is the ethical side of it. It is how can we take the bias out of the artificial intelligence to make sure that it is neutral. That would be another problem. » « This is a problem about, you know, that the driverless I mean, we're not ready. There are multiple types of artificial intelligence. We're talking about the general one. We're talking about, you know, the super artificial intelligence. We are still at the first level of artificial intelligence. We cannot replace everything about what the human doing, the work with the human. There's a lot of collaboration and cooperation. We still need the human factor. We're going to get to the level where they will work by themselves at the second level. And then

you're going to get to the super, which is artificial super, you know, the super artificial intelligence where they're actually going to control us because they see us as trouble for them. And that's the timeline is about another forty-five years if we continue with the speed of developing the artificial intelligence. So that's another problem with it, which is it's not complete. There's so many things still we have to add to the to the model before I can say this is a safe autonomous car, a safe automation inside the factory. »

Daniel Yasri : limites de l'AI, c'est que tu peux faire seulement ce qu'on programme. C'est limiter à des problèmes complexes qui nous semble limité en termes de rapidité et d'enjeux mais qui sont en fait des problèmes simples. (...) elle ne peut pas conscientiser les choses. Elle ne peut pas faire un choix moral, elle ne peut pas changer de plan au-delà de ce qu'on lui a donné déjà. l'IA demande une puissance de calcul qui est quand même énorme, donc au niveau des coûts, de qui peut le faire, comment le faire, c'est difficile. (...) les données puissent être traitées par quelqu'un qui n'est pas humain, ça peut poser problème. Ça amène à l'autonomisation, ça peut aussi inquiéter par exemple les radiologues, on a vu qu'ils pouvaient mieux lire les images que les radiologues, donc ça peut avoir un souci au niveau de l'emploi pour certaine personne. (...) l'absence de prise d'initiative, c'est une grande limite de l'IA. Elles ne peuvent pas faire des choix défiant leur fonctionnalité de base. Le choix des machines repose que sur l'optimisation et ne prend pas en compte la complexité des situations. Mais vu comme ça déjà, ce n'est pas une limite que la blockchain peut résoudre (...) Le pooling de data pourrait aussi être un problème. C'est quelque chose dont on a déjà parlé, l'AI, pour fonctionner au mieux, elle a besoin de données qualitative. Et donc ces données qualitatives peuvent être quelque chose très difficile à obtenir et à certifier »

Julian Fifiield : « Artificial intelligence is pretty much a waste of time, unless you may as well just leave normal data analytics unless you've got powerful, accurate data. »

Joan Van Loon : « It's the main challenges are around bias, which means that in the beginning it was said, well, AI is better than humans because computers are not biased. And where humans are, we found that that is no longer the reality. So also computers, also A.I. is biased. And the reason why it's biased is for two reasons. One is that data in itself might be biased. (...) Because in the past there was much more data for that specific group (...) But the second thing is that humans themselves are still biased and it's humans that basically programmed the system. » « The second thing is about trust and transparency. So and certainly in certain areas, like, for instance, health care, and this is this is crucial. You cannot let a system tell a doctor what the right diagnosis is or what the right treatment is without being transparent on how you come to that conclusion. And a lot of AI systems that have been built are these kind of black boxes, so there's nowhere that they describe on what information does it use? How does it use the information, how those processes, the information and how does it come to a conclusion? It just puts you put in a question and you get an answer, but the process in between is a black box » « So that transparency is needed to have people have trust in A.I. So for a doctor to be able to say, yes, I'm going to follow this decision, I'm going to follow this advice » « the trust and transparency is a very crucial thing. And this also relates directly to the data. Can the data be trusted? Is the data ethical? And again, that depends on the quality of the data that depends on the source of the data. »

Philippe Coucke : « C'est une problématique plutôt culturelle. Je pense au niveau de l'adoption de telles technologies dans le monde médical qui est excessivement conservateur. Nous avons l'habitude de rester assis sur des silos de données qui nous sont propriétaires entre guillemets. Et on a un mal fou à échanger. Le deuxième, c'est l'interopérabilité également des systèmes. Il faut savoir que pour pouvoir échanger des données, il faut y avoir accès. La problématique, c'est que à nouveau, beaucoup de logiciels que nous utilisons dans le monde des soins sont à nouveau sous un format propriétaire et n'échangent pas les données avec d'autres systèmes. » « Il y a ce sentiment de la plupart des soignants qui sont en fait en face d'une boîte noire dont ils ne connaissent pas le fonctionnement. Ils ont du mal à faire confiance aux conclusions qui en sortent. Il y

également à la problématique des données. On revient sur la problématique de base, la valeur des données, la qualité des données. Parce que garbage in, garbage out. Et aujourd'hui ça pose énormément de problèmes au niveau médical, car il n'y a pas de standardisation de la manière dont on enregistre les données dans les dossiers médicaux. Donc pas de formatage, très peu de données qualitatives, très peu de menus déroulants, très peu de question et de réponses booléenne, oui non. Si on ne résout pas ce problème là, le big data reste un leurre. On a parlé également de l'interopérabilité, qui est encore un autre problème. Puisque on couve jalousement nos données, on n'est pas prêt à partager avec d'autres. Tandis que dans un écosystème de big data, il faut un maximum de données provenant de différentes sources. » « Les logiciels automatiques d'intelligence artificielle capables de reconnaître des problèmes dans la race caucasienne, mais totalement incapable de le faire pour la race africaine. C'est l'exemple typique du biais. » « la philanthropy des données et donc en fait, les gens se gargarisent avec privacy, mais nous sommes dans un monde où je pense et c'est malheureux de le dire, mais c'est un constat mais le privacy n'existe plus maintenant en moins de 3-4 clics, si vous êtes sur les réseaux, on arrive à vous identifier. On sait exactement qui vous êtes. Donc, honnêtement, privacy est un leurre. J'appelle à la philanthropie des données. Je suis un citoyen, j'ai des droits, j'ai des devoirs, je mets mes données à disposition pour qu'ils puissent servir au plus grand nombre. Dans un contexte de big data. Mais je suis aussi conscient que je ne veux pas que mon dossier médical figure sur la première page de la Meuse. Qu'il soit accessible dans un contexte d'analyse de big data. Mais il faut bien entendu mettre en place des garde fous et des garde fous peuvent être mis en place par une technologie de type blockchain où on contrôle qui amène l'information et qui l'utilise. » « Il est clair que si vous avez une intelligence artificielle dont l'algorithmique est continuellement en train d'évoluer, se pose bien entendu la question à qui revient finalement la responsabilité à un moment donné. Il est clair que si vous avez un algorithme d'apprentissage non supervisé, plus personne n'est responsable parce que vous ne comprenez pas l'évolution de l'algorithme et donc on ne peut pas reprocher à un humain que la situation dérape. Là se pose éminemment un problème éthique et juridique. » « Il faut que ça reste très dynamique. On sait très bien que la transformation des données vers des informations utiles dépend fortement de la quantité des données qui vont affluer et ça peut aller très, très vite. Les modifications des algorithmes entre guillemets, un algorithme peut muter trois fois par seconde en fonction des données qui rentrent. Comment assurer, en effet, que vous ne figez pas le système? » « l'intelligence artificielle ne remplacera pas le médecin, mais le médecin qui n'utilisera pas l'intelligence artificielle va disparaître. »

Hasen Kapasi: « One of the biggest one is data. Everybody wants to have AI algorithm. One of the biggest challenges is getting that data right, because at the moment those algorithms need to have a specific data that they can understand. And at the moment, companies have different maturity. So if you're buying a company, any healthcare company or any of the company, they hold their own functions working and they have their own data silos at the moment and everybody has their own terminology. So if you really are looking at the healthcare sector, they have their own different language. And then the data have to be cleaned in those languages. And getting the data right is, I think, one of the biggest challenges. »

Robert Miller : « We do not have the right relationship between users and algorithm owners or trainers and I think if we could develop systems that treated people more like stakeholders, where I'm providing data to the system in return, I'm getting some sort of value, my contributions are being recognized as valuable and treated like a true stakeholder. The way that it works today, algorithm trainer like Google, Amazon, etc, they do everything possible to let you know that you're there to try and keep you from knowing that your data is being used to train an algorithm. But it's pretty cool that my information is being used at Amazon to generate all these recommendations. And Google was using my captcha in order to train self-driving cars. And I think if you reframe this relationship, you treated people as true stakeholders, then they would want to contribute

	more and maybe they would contribute to higher quality data. No one has figured out the right way to frame this relationship and I guess it's like the socio economic context in which our lives are created. And I think that's a big problem, especially if you think that algorithms and the data economy are going to grow much larger than if people are not treated as true stakeholders. They're not going to capture any of the value that is created by this economy. And then the most training of algorithms is all done in centralized context. You send all of your data to Google, they put some training for algorithm on top of it. In health care, information is super sensitive. And we've seen what happens when you send a ton of health data to Google, there's a huge amount of uproar. People do not want Google to have their information. And so centralizing data is not a viable strategy in the context of healthcare. We need ways to train algorithms that keep data private at the edge or at least within the confines of a hospital patients trust. It is only through decentralizing it can happen. » Natalia Monteiro : « there is a lot of discussion about replacing employees. What I believe is that AI actually is enhancing, you know, our cognitive capacity. It's not to replace, but it's to work next to it. I understand it will be replacing a lot of low level jobs. » Jonathan Passerat : « Je ne sais pas si on va arriver à faire de l'intelligence artificielle générique avec les techniques qu'on a aujourd'hui et avec le matériel qu'on a aujourd'hui, je pense qu'on est en train de devenir très bon à résoudre certains problèmes, la reconnaissance d'images, la traduction de textes, des choses comme ça, ça, c'est devient la compréhension de Speech recognition. » « les techniques sur lesquelles on s'est orienté aujourd'hui de deep learning. Elles ont deux contraintes assez lourdes pour moi, c'est que déjà, elles demandent énormément de données pour pouvoir arriver à un résultat cohérent et elles demandent en même temps énormément de temps de calcul. » « Donc, j'ai peur qu'on soit dans un monde, dans un système où la recherche académique avance plus vraiment dans ce qu'elle devrait faire. Pour moi, c'est ça le gros ou la grosse contrainte. On est tous en train de s'enfermer dans ce Fano du deep learning, alors qu'en fait, les seuls qui peuvent vraiment avancer de ce côté là, ce sont les gros. »
Governance & Legal	Daniel Yasri : « Si c'est toi qui as pris la décision, c'est toujours l'humain. Et il y aura toujours une validation humaine. Si la machine est en total autonomie, ce sera celui qui l'a créé qui sera responsable, si c'est toi qui à décider d'écouter la machine, tu es responsable. » « Par contre remonté pour qui a fait quoi, qui a pris telle décision à tel moment, si c'est placé sur blockchain et par AI combinée ou juste sur Blockchain, oui c'est possible. Par contre au moment de la prise de décision, non. La blockchain ne va pas aider. Tu peux enregistrer la décision oui, et ta décision, si tu as décidé d'écouter l'IA ou pas. » Joan Van Loon : « Yeah, because that's basically what, so blockchain manages the process. So the governance of the process of knowing where the data come from, who has sent which data to whom, who has who has changed the data, who has added data and things like that. So the full governance of the data between, for instance, a hospital and a patient and a doctor, that's where blockchain works perfectly. Legally also to indeed have an auditable trace and an audible tracking of where the data comes from. So if you have your final answer, you can auditability track like, what data, what information has been used to come to that answer? Where does this data come from? Who has provided the data? What is the source of the data? What is the quality of the data? So in that way, it can also help the legal process. » « the machine is the machine is never responsible and the doctor will never be able to claim yet well, I took this decision, but the machine was wrong. I mean, that's not the way it works. That's not the way it's set up. That's also why that the final element in it will remain in human decision supported by underlying information. But I mean, again, this is what most of the time has been discussed here. But then the doctor trusts the machine and then the machine might be wrong. OK, but what does the doctor trust? Does he trust his or her gut feeling or an article they've read or the experience of a colleague? So again, now they will trust a source of information which uses much more information so which goes much broader, which basically includes everything which is possible to include with even the way to check on how it got there. So

	we're way further than today where a doctor read an article about a certain drug and reads that drug is good for that kind of disease. I will prescribe the drug. So also then as a patient, if the doctor prescribes the drug, you're not going to ask, like, why do you prescribe this or have you read this? Can you prove that this drug is the best for me? » Robert Miller : « It's like always that thing that's on the horizon, people keep on talking about. Nobody ever seems to do. But yeah, the governance is interesting because it will allow groups of people to control algorithms and to make decisions about the algorithms in a way that's not possible today. Like I was describing you earlier, Federated Learning Networks. So I really like this idea of collectively owned, collectively governed algorithms. » « in a federated learning network where you're training algorithms on people's devices, you can have a blockchain, decide what is trained and when and actually execute the different steps of machine learning that are taken, like run this file on this data at this time, and individual artist could mark the data that they are interested in contributing or not. And you could have the algorithm and its execution governed by what the members of the network collectively say. The way that the software that we're building works is you might have a network of five hospitals in our Federated Learning Network and only if all five say that they want to have an algorithm trained on their data in this Federated Learning Network will anything ever be run on their local infrastructure. And if one hospital says no, they'll either opt out or the algorithm won't run at all. And so in this way you can have the network decide what is run instead of one party decides what an algorithm runs or not. » Hubert Ridolphi : Ça se gère au niveau de l'entreprise.
Privacy & Cybersecurity	Daniel Yasri : « Tout à fait, j'espère que tu fasses une blockchain public pour une IA, donc tu n'auras pas de 51%. Tu ne peux pas faire de 51% sur une consortium où sur une privée. Les 51% d'attaque c'est ce que tout le monde va dire et c'est un mot clé que tout le monde va faire semblant de comprendre cela. Par exemple, sur une blockchain privée, ce n'est pas possible. Le 51% d'attaque c'est surtout sur le proof-of-work puisque c'est pour dépasser 51% de la vitesse de hachage. Il faut déjà avoir 51% des assets. Donc il faut avoir 51% des bitcoins. Il y a 10 000 000, ça fait 5 000 000, le bitcoin fait 10 000, ça veut dire que l'homme est le plus riche du monde. Donc oui ça existe dans le proof-of-work si quelque déploie une puissance de calcul supérieur à 51% de la totalité du réseau. Mais pas sur une blockchain privée, etc. »
Discrimination and biases	Ahmed Banafa : « Blockchain can help AI with providing good data (...) So having a nice data, a clean data, a data that we can trust, it's going to reduce that 80 percent we spend on clean it. It gives us more time to find a better model when using AI. So that's how they work together. » « So it is a software written by certain people. If they have bias is going to show up in the software. That's why you need somebody to check it. You have to have some rules for ethics. Microsoft, they have the rules of ethics for the artificial intelligence that it should do. One, two, three, four, five, six, seven. Every time you see any kind of bias, you shut it down completely. » « And blockchain can help as you have the same information without any modification, if I have, if I'm in a certain country and they do not like me, they can change my information. But if it's in the blockchain, it's going to stay the same. So the identity, protected identity is very important. Also for keeping the people instead of changing the information. You know, somebody is a fugitive running away. Even if you have a different name, there is other things that will say that who you are. That what is identify. » Daniel Yasri : « C'est plus une erreur matérielle ou humaine. C'est une erreur de programmation. C'est que les personnes n'ont pas codé les contrastes, etc. En effet, on peut dire que c'est dû à un manque de données mais également par un manque d'intelligence du côté humain » « Pour moi c'est parce qu'on a lancé l'AI sans lui donner les moyens. On a fait ça pour un certain sous-groupe de personne. Après est-ce que la blockchain elle a vocation à répondre à ça, je ne pense pas. C'est les gens qui codent cela à l'avance qui doivent savoir qu'il y a des gens métisse, chinois, etc à la base. Il faut que ce

soit déterminer avant. Ils ont codé le modèle sur certaines personnes ». « L'IA a des biais qu'on lui donne, une fois de plus ce n'est pas quelque chose que la blockchain peut résoudre. »

Joan Van Loon : « It can help indeed validate where the data comes from and if the data is again is correct and of right quality. But the bias as such will only be removed by having more data. So blockchain in itself will not remove the bias. So the process to remove the bias is a process of making sure that you use enough data to come to the right conclusion. »

Julian Fifield : « All the horror stories you've seen in the press where because they've got bias in the system, you know, you get agents spitting out racist. There is a lot of issue to deal with bias and data sets. There is a big problem there. Machine learning and artificial intelligence is super important, super powerful, super transformative and blockchain is a very powerful way of giving accurate and useful data to work on. »

« It forces you to go through this process of identifying what the data points are and what the truthful data points are. It forces you to do this. If you do not do that effectively, you've got untruthful, dirty data passing through the system, just like you have in a normal database. So again, done right, it forces you to address the questions up front. You can overcome some of the biases at the beginning. You do not just take the dirty data for granted. You can think about an open and transparent way, what you're trying to collect, why you're trying to collect it, how you collect it before you start. So you should go through the open and transparent process. Make sure that you're not being biased or you're relying on biased data. Because effectively you're able to pool in and agree in a governance framework exactly what a trustful and non-bias data looks like. » « There is a bias. The machine isn't biased. Those rules were written by biased people. So the algorithm reflects the bias of the people and reflects human bias. » « And this will be provided by blockchain, this governance, mechanism to avoid it? I do not really see the link with blockchain and at this time. Julian Fifield : Well, I suppose the truthful answer is you do not need blockchain either. Meriyem : OK, so here a blockchain cannot be related with A.I. at this part. We cannot use blockchain to reduce discrimination done by AI. Julian Fifield : No, I wouldn't say that. I think you can help that out by agreeing the rules. Of data collection and eliminating bias upfront, and then you have a tamper proof record. So I think it could help. Absolutely. Well, it's not the only way of doing it. There are other ways as well. It's not essential. »

Bill Inman : « Meriyem : if we ensure that the data are untampered and then we are going to use them for the machine. So it prevents also from bias? Bill Inman : Here we go. »

Hasen Kapasi : « I think that for sure. As I mentioned, that's it and quality. »

Robert Miller : « The first way is in providing a better sense of what data were used to train. You see all these headlines of people doing things with algorithms, but it's usually just like a bunch of white people in America that their data has been used to train. And in particular, this is really bad genomics where we have great coverage of Western Europe and America and that's like all of our genomic data, but no one else in the world. But anyway, so having a better sense of what data sources we're used can help you decide whether the data is really representative of the population that an algorithm is being used for. And then in this future state where you have blockchain networks that are training algorithms and facilitating the training of algorithms, these are neutral and open networks that aren't going to discriminate against any person. »

Natalia Monteiro : « But with A.I., you can actually solve that and that's what this scientist is working on. She is actually utilizing A.I to filter just the female results of the studies and to provide more accurate data. So creating more personalized medicine for females. And that's what I find so powerful. Yes, it can create biases, but by recognizing where the mistakes are, you can utilize the same system that creates the bias to actually personalize it. »

« I would like to wrap this up is that I do not think the blockchain helps AI. I think it's vice versa. I think it's artificial intelligence tapping on the potential of blockchain, because now if we go back to the beginning of my answers blockchain is actually helping decentralized

	databases being connected so that mental hospital, the heart hospital, the dermatologist, the GP, imagine that all this data remains in their silos, but via the blockchain, the patient actually can collect specific data from the different silos. Now, if you put an AI model on top of it, then you actually can tap on all the information that is collected and secured and kept in the silos. So whatever you ask your AI model to do, he is now actually having no boundaries. » « And can it help them with bias to reduce bias because the data or quality data. Natalia Monteiro : Yeah, yeah. » Jonathan Passerat : « Je pense pas que ça soit la clé pour amener plus de confiance dans l'IA. On va dire que ça, ça peut permettre d'amener de la confiance de manière indirecte si on arrive grâce à une infrastructure de blockchain, à créer par exemple une économie de la donnée ou du coup, on arrive à accéder à des données auxquelles on n'avait pas accès avant. Et par conséquent, on devrait avoir des modèles moins biaisés, plus génériques si on arrive à avoir accès à des sources de données plus variées, mais ça reste une affaire indirecte. En fait, je ne pense pas que ce soit la blockchain elle même qui fasse ici. » Tim Richmond : « Bias is a really tough one, because every time you have a container of data, it will always be biased because it doesn't contain everything. And so particularly with algorithms. So we can train algorithms to generate other algorithms. So what you get is you get an algorithm that's designed towards a specific goal, but the goal that you set is automatically biased by the very nature of what it is. But if you can create an algorithm which is designed to create other algorithms, then you can eventually get to a point where the original bias is already minimized. But blockchain, when talking about blockchain specifically, one thing is you can create something called a consensus decision making. So this is where you have different algorithms pointing towards the same outcome and then using blockchain to interconnect these algorithms, you can create a central algorithm which then is able to take the data and even it out. But even then, the algorithm is biased in its own way. So this is a major, major problem and something for which there isn't a solution properly yet (...) big data is actually one way to reduce the bias, because you've got access to all the data. So blockchain although it seems like a distributed ledger, being distributed in itself would be one solution to a bias because it creates an equilibrium within the system. At the moment, you introduce any A.I. that is working on a data set, you're introducing bias. And so the only way that I can see that this can resolve is if we interconnect with big data to be able to just have access to as much data as possible. I do not think you ever going to be able to reduce the bias down to zero » « But then blockchain could help maybe with accessibility data to have more data available for training the AI and to reduce for example, discrimination. And we can also access more data from all around the world more easily. And the big companies are not the only one that have access to the data? » « Absolutely. The more data you've got access to, the smaller the ratio of bias is. Absolutely a very good point there is that large organizations obviously contain the ability to control this data, meaning that they can make decisions which are good for them, but not necessarily good for everybody. » Hubert Ridolphi : « On le voit dans les robots qui vous répondent, c'est du machine learning derrière, et les réponses ne sont pas toujours appropriées parce qu'elles ne sont pas culturellement teintées. Donc oui, vous avez tout à fait raison, mais ça n'a rien à voir avec la blockchain. »
Trust issues from patient or doctors	Ahmed Banafa : « Internet is about connectivity blockchain is about trust. That's the key thing. » Daniel Yasri : « Bien sûr, ça diminue l'erreur. Que quelque chose ait mal été copier. Tu es sûr qu'avec la blockchain c'était comme ça. Il n'y a pas d'erreur sur le fichier, il ne manque pas d'information, d'information perdue, sinon tu n'aurais pas le même hash, etc. Et les datas, sont plus safe, de qualité, intègre, etc. Mais les gens n'ont pas confiance en l'IA, parce qu'ils n'ont pas confiance dans une machine. Ils n'auront pas plus confiance si on leur dit que c'est prouver, timestamp. Ils vont te dire je m'en fou de croire une machine,

je veux un humain. Il faudra donc un travail d'éducation et montrer que l'IA fait plein de bonnes choses. »

Philippe Coucke : « Je ne sais pas très bien ce qu'il faudra pour qu'on bascule réellement vers un modèle tel que celui-là »

Joan Van Loon : « In a way, so blockchain is kind of like a ledger, it's a process, it's kind of like different steps in a process which are automated and you always know where the data comes from, who has approved the data, who has done what with the data. So in that context, so if you talk about having quality of data, checking the source of the data, of course, that blockchain can help it because it can fully validate the process of where does the data come from. Who has worked with the data, who exchange the data, what is the quality of the data? So that is a way where where blockchain can help with regard to trust in a way also because if one part of the trust is knowing where the data comes from and knowing how the AI comes to a certain conclusion, then it can also help, but it will not be able to help with the trust in the decision process as such. Because the transparency that you want to create, so coming away from the black box principle has nothing to do with the process as such, but has more to do with the description and the openness of developers to show how they have developed. So there's a step before the blockchain part. So you first need to open up the system and then blockchain can help to validate what you're claiming in your transparency is true, but Blockchain will not help to open up the transparency as such. » « It won't completely solve the problem. It will help in a bit just for the aspect of knowing where the data comes from, knowing that it's qualitative data and knowing that it has not been tampered with. So for that aspect, yes, but it won't help with the process of trusting the fact that the machine has gone through all the data and can't come up with an outcome because basically blockchain does not control that outcome. blockchain is it controls the process, controls where the data comes from, but it does not control the algorithm, the machine learning as such that is not what blockchain can do. So you have to have a certain trust in in the fact that, well, the machine used this information and comes out with this outcome because combining all these different studies, all these different information, all these different evidences, this is the best outcome. But it will never be able to to fully, completely trust that if you do not trust it. »

Julian Fifield : « But you've already got examples of machines working with people to eliminate, to help eliminate mistakes, false positives and false negatives. So these things will only gain in time and therefore, trust will be. We'll grow in time and it won't be long. I do not think it'll be long before when you go to the hospital, you're talking to a human, but there's a machine sitting side by side with the human giving, helping the doctor. That's ideal. But I think blockchain can help gather the accurate data and the like. But as I said to you earlier, it's not the only way of getting it within the system. At all. So it will vary depending on the use case. But within the health care environment, it is probably not going to help with X-rays. »

Bill Inman : « Well, blockchain, it is going back to this main point, it's going to store the results and the variables that made the decision over time. By the way, we do not need to see the full record. We could just say this 48-year-old woman had breast cancer, she was a smoker. Here's what we know about her diet. And that information can be published for public use, but we can track that over the forty-six or forty-seven, forty-eight, all these different people over time. And we can see that, oh, that was biased towards women in North America. But for women in Europe, that doesn't really apply. Without the immutable record again, it's hard to combine data, much harder to combine different data transparently or even anonymously. But this really will help with the trust around the decision making process, whether the AI was biased or not. And it helps with transparency and explainability. »

« So, you know at the moment why they are facing this problem is because if you go to any specific company or any specific hospital or any specific institution requesting this research, and they come to you and say, OK, you know, I want your data, medical reports, which is quite possible for the research. And they really do not trust us because they really

do not know how they're going to use it and they do not have any transparency. And that is why and I think that is a common culture in Europe that they are really hesitant to share the data. Right. So I think that is one of the biggest challenges. But then if you have an app where you see, these are the purposes we are going to use your data because this is not the institute which is going to use your data, this is not the topics for which we are going to use our data. It can be used for a specific timeframe for the next six months. And then when it is being, you know, you will get a notification. When you get when it gets deleted, you will see in your app you will be rewarded. Right, for the use of the data. »

Hasen Kapasi : « The trust will control the system. But ultimately, the core of the system is data. So if that isn't in blockchain, there is garbage in and garbage is not out and blockchain can help. Otherwise, the garbage stays in. »

Jonathan Passerat : « Quand tu fais du machine learning en réseau entre plusieurs sites qui collabore pour le coup, mais qui ne sont pas forcément amis, qui peuvent être des compétiteurs. Ils veulent avoir la preuve que ce qui s'est passé est vrai. Une des manières les plus simples, en fait, d'utiliser la blockchain dans ce contexte, c'est de s'en servir pour comme un journal d'évènement irréfutable où tout ce qu'on fait sur les données dans un réseau, on va le logué sur la blockchain et tout le monde va participer à ce réseau. Et du coup, on va augmenter la confiance en fait du processus d'entraînement du modèle de manière distribuée. » « Confiance?: J'ai du mal à voir pourquoi la blockchain amènerait quelque chose en ce côté là. Je pense que les techniques d'explicabilité de l'IA auront un impact plus significatif dans ce domaine là. Si on comprend mieux pourquoi l'IA prend telle ou telle décision. Je pense que ça sera beaucoup plus puissant que de coupler ça avec une blockchain. » « Oui, je pense pas que ça soit la clé pour amener plus de confiance dans l'IA. On va dire que ça, ça peut permettre d'amener de la confiance de manière indirecte si on arrive grâce à une infrastructure de blockchain, à créer par exemple une économie de la donnée ou du coup, on arrive à accéder à des données auxquelles on n'avait pas accès avant. Et par conséquent, on devrait avoir des modèles moins biaisés, plus génériques si on arrive à avoir accès à des sources de données plus variées, mais ça reste une affaire indirecte. En fait, je ne pense pas que ce soit la blockchain elle même qui fasse ici. »

Robert Miller : « It's a complex problem, but I think it helps and in some contexts, I mean, a big problem with AI is figuring out how it came to its conclusion. And there are all sorts of people right now that are training AI that will identify lung cancer or make some predictions or this or that. But oftentimes these things are just like thrown out into the world and you have no insights into how they came to their conclusions. And there is no way to reproduce them, which is a central principle of the scientific method, is the reproducibility of findings. But you just can't do that with most AI. And I think it is interesting to think about how a blockchain can help solving that part of the problem of providing an audit log of the particular actions that were taken and the data sets that were referred to such that a third party could go back, take the same actions with the same sets of data and come to, in the same code, to the same conclusion, the same algorithm, and to be able to reproduce what was made with a lot more integrity and trust. And that's not possible today. So I think that would add general trust in addition to training and training data that has more integrity, that has been posted to a blockchain as well, I think would be useful. But about the steps taken to the decision : This is unfortunately a problem that blockchain cannot solve. »

Hubert Ridolphi : « J'ai un peu de mal sur comment la blockchain peut apporter du trust par aux données dans l'utilisation d'une AI, je dirai que le trust vient du consentement du patient ou pas et qui doit être dynamique. C'est là où je vois le trust en premier dans la mise en place de ces systèmes. La blockchain, après c'est un outil pour voir que ce sont les bonnes personnes qui accèdent aux données, ça, ça peut être totalement utilisable pour ça. Donc pour le public, est-ce-que la blockchain peut amener le trust pour l'utilisation de l'AI. Ça fait 2 buzzword dans une question, AI et blockchain et je pense que le public n'est pas encore près à ça. »

Transparency and explainability

Ahmed Banafa : « You have the traceability of that one, and if there is a weird answer, they're going say, I think this is not right, I can go back and check. How did it get this? How did you get this? You can go back and check the information and it's available right away. It's the software. You can have it on the screen. You do not have to go and look for the record. You do not have to do anything about it. And if this doctor sees it, another doctor can see this one and say, yeah, I mean, the trust is a big factor here, which is whatever you have in that system, you can trust it. Nobody can change it. Now, if the data itself is wrong, we can verify this one. If somebody said, you know, the results of the lab is so and so, well, I think this is the problem. Then go on, check it. At least I know where is the issue, because I have this kind of a track of the activities instead of reinventing the wheel and start all over again with the process. I can't just go and look at this one and this one and say, OK, that's the thing. Many times you're going to find somebody who's changing, his doctor will take the x ray and show it to the doctor. Doctor will throw it away. So I want to do my own x ray. But what about if this one is coming through the computer from the blockchain and say he or she did this kind of analysis and x ray, this is the result by Dr. So-and-so in the hospital and the machine used for this one and so on and so on. This is the time. I would feel more comfortable when you tell me about it this is the source of this information. » « The other side is the blockchain can document all the progress of the A.I. You hire me to analyze a big set of data for, let's say, for your retail stores. You own thousands of them in the world and you get this data. You'd like to analyze it. Every time you get a result or you do something with the AI model, you document this one on the blockchain. So later on like two or three months from now, when I get the result, you came to me and ask me, I do not believe this is right. Where did you get this data? Then I can go to the blockchain and I say, OK, at this time, this is the data. This is the result we have. So it's a documentation of the progress of processing the data and getting the insight. »

Philippe Coucke : « Ça permet un tracabilité. Mais le problème c'est est-ce-qu'on peut permettre un apprentissage en continue non supervisé? Ça je n'en sais rien et ça me semble difficile parce que la vous arrivez à un certain step et vous le bloquez. Pour continuer à alimenter un algorithme de nouvelles données, il va continuer à évoluer. Et est-ce que votre blockchain par la suite est assez dynamique pour suivre le mouvement. »

Daniel Yasri : « Il faut vraiment que tu parles du hash, des signatures, des clés privées, de clé publique et que vraiment, l'intégrité et la provenance des données, la blockchain excelle dans ça, c'est fait pour ça. » « Si par exemple, on a une AI qui fait du ML et qui choisit: lui il faut injecter, lui il ne faut pas injecter, etc. Oui ou non quoi, un truc binaire. Et que en fait, c'est en fonction de certain critère que tu as prévu, quand tu as codé cette IA, ben de pouvoir voire quel chemin il a pris. Il a des branches et il prend la branche de droite, celle de gauche, etc. Et ça fait un arbre de décision jusqu'à arriver à la décision. Si par exemple, tu décides que ce qui serait intéressant de mettre chaque arbre, que l'IA prend la décision et l'enregistre sur la blockchain son arbre décisionnel, alors oui. Dans ce cas-là, ça répond à ta problématique. Tu vas dire, ok il y a eu un problème, je veux savoir ce qu'il s'est passé, parce que tu vas pouvoir dire, il s'est passé un problème. On va te dire, moi je pense que c'est l'IA, tu vas dire non je veux être sûr, tu peux me prouver, me montrer que c'est à telle heure qu'il a pris sa décision, et que c'est arrivé? Tu vas sur la blockchain, tel hash, timestamped, ok ça correspond exactement à la décision et en plus, est-ce-que tu peux me sortir l'arbre décisionnel? Ben oui parce que on a enregistré la décision sur la blockchain. Donc oui, une fois de plus, elle a été signée par notre IA à telle heure, c'est bien la décision qui a été prise à cette heure-là, donc on peut le vérifier. Ça peut aider, mais il faut que l'IA, et les gens qui codent l'IA, la code de manière à ce qu'elle enregistre sa décision et qu'au moment de la faire, elle aussi elle la valide via la blockchain. Et qu'elle met son arbre décisionnel sur la blockchain. Mais le oui, ça pourrait être utile en effet, parce que tu veux tracer quelque chose, son intégrité et sa provenance de manière certaine. Donc tu veux être que ce soit bien maintenant, que ce ne soit pas le patient d'avant et tu peux le prouver. » « C'est vraiment de la signature une fois de plus, du moment, de l'endroit, de l'AI, de la personne concernée, où un arbre décisionnel

aboutit à un hash et où tu peux vérifier que c'est bien le moment et l'endroit où il a pris la décision et comment. Tu pourrais le faire sans la blockchain, mais grâce à la blockchain, tu pourrais le certifier d'autant plus ».

Julian Fifield : About blockchain helping to explain a decision : « I think you're ahead of the time. I can't see a way of doing that at the moment, but maybe that's me. »

Bill Inman : « What AI can do, especially for purposes of AI or explainable A.I., is it can store its information and whether it's biased or not, just kind of look at what what it's shown over time, be explained in a blockchain. So that way there's no question that this A.I. said this about this » « It should store the results. Blockchain should be used to store the results for every transaction, like the end results and how it got there, what are the data point. » « So let's say that there is the choice of ten data points to come up with the decision, but it only uses eight of them as opposed to ten, because that's just what it means. Then the 8 data points that should be stored on the blockchain plus the final result so we know what variables and what data inputs created what result. And over time, we can take a look at that with maybe other AI agents to say, well, that was biased towards this type of person or this type of affliction or disease or we may come up with the results that it just works better for this type of cancer. So having an immutable record allows us to, with trust and with beliefs, understand that. AI agents like blockchain to store transactions to be trusted. Not that they're unethical, although some AI might be because there programmed to be it, but just because it's better suited to do. The algorithm was better suited to do this. And here's the proof. Without that proof, then you have metadata that could be manipulated and then people want to sell their AI saying it's better suited for breast cancer. Here's why. But how can you trust it? It is not immutable. »

Hasen Kapasi : « I would say that of the key features is time stamping. Blockchain can actually cover each of the times and each of the steps which happened during this process. So an AI based algorithm says OK it analyses this data, this data and based on this analysis this is the result you are getting. Blockchain can trace each of the step and you can see it and structure those processes. How you want to build the transparency in blockchain totally depends on how you develop the platform. » « It's possible, I would say, because you need to understand the architect system. So where do you put blockchain? Blockchain is basically, you have two possibilities, on chain and off chain. What is off chain is basically you are hosting the blockchain on a cloud solution. What you are storing only on the block chain is just a hash of the data, kind of a signature of the data or any PDF file. In terms of that, that is a diagnostic coming out of that algorithm. And if you want to store that diagnostic, it will be stored on the blockchain as an event which you can review it so you can actually see it. »

Robert Miller : « I just gave you of an audit log of actions that were taken with data that are posted to a blockchain that somebody can go back and look at and see, you know, here is what I did, It's been used for what context and by who. That will let people have a lot more insight into what their information was being used for and a lot more trust in sharing the data. »

Natalia Monteiro : « I do not see the need to trace AI because when you look at the the model itself, you can always go back just by the model itself. You know, you can always understand how it has been calculated, at least the ones I've worked with so far, the calculations. So you see how it has done a certain estimation. And you can look into this so you can look into to record. But for for a doctor, it would make really real sense. AI model can already recognize cancer. OK, so how would the doctor tell better? You know, because this is based on hundreds and hundreds of comparisons of pictures with pictures. And this is always evolving. So, you know, they learn from their mistakes and then they keep in involving so that tracing the diagnostic, I find it doesn't need to be on the blockchain, to be honest. But I think it's important is actually to utilize A.I. where is really needed » « And that's what I find powerful of this whole system, but to trace how that A.I. model has worked, I find it either is just pure ignorance from my part because I haven't really looked into this or I'm missing this opportunity. »

	Jonathan Passerat : « Ca dépend. Si ça veut dire que l'IA est sur blockchain, je ne pense pas que ça soit possible à l'heure actuelle. Si on veut faire de la vraie traçabilité je pense qu'on pourrait, si on sait exactement, quand tu as un modèle d'IA, tu vas pouvoir lui demander des tâches très précises. Tu vas l'entraîner pour faire quelque chose. Tu vas dire, je te montre une image, dis-moi ce que c'est, c'est un chat, c'est un concombre. Des choses comme ça, en fait. Donc, si tu as un système complètement intégré sur la blockchain, qui dit bah. J'ai fait une action. C'est un événement, c'est une transaction sur la blockchain. C'était quoi mon action ? C'était demander une information à l'IA OK. L'IA, elle me dit quoi ? C'est quoi sa réponse ? C'est loguer aussi sur la blockchain. Qu'est-ce que moi j'ai fait avec cette information ? Est-ce que je peux le loguer sur la blockchain ? C'est comme ça que tu peux avoir cette traçabilité, en fait je pense. Et ça effectivement, ce n'est pas incompatible. Il y a des papiers assez marrant où tu as l'IA qui elle-même et dans un smart contracts, par exemple sur une blockchain publique, je pense pas que tu puisses faire ça parce que tu vas avoir des notions d'IP qui vont entrer en jeu ou si tu as des IA qui sont très compétentes que tu ne peux pas divulguer, tu ne vas pas forcément les mettre à disposition sur une chaîne publique, en fait, comme ça, pas en clair on va dire. » « Je pense que pour répondre à la question de traçabilité, ça pourrait aider. Mais d'un point de vue de haut niveau, on saurait quel algorithme qui a pris cette décision et a répondu ça. Maintenant, est ce qu'on peut mélanger toutes les thématiques de l'explicabilité des décisions de l'IA, c'est un domaine un peu connexe. Je ne suis pas expert dans ça donc j'ai du mal à voir si ça pourrait aussi être combiné avec la blockchain, est ce que tu pourras finalement ouvrir la boîte noire de l'IA et dire Bah, non seulement j'ai accédé au modèle, mais en plus, je sais que le modèle a fait ça, ça et ça et ça comme décision pour arriver à son résultat. Si c'est le cas, oui, du coup. On pourrait juste en fait descendre d'un niveau de zoom et ouvrir la boîte. » « Justement, par exemple parce que si, si, ma données est référencé sur la blockchain, juste un identifiant, c'est juste un identifiant pas ma donnée exacte, je sais que monsieur X est en fait il a telle données qui est disponible. A chaque fois que je vais donner l'accès à quelqu'un, finalement, je vais accepter son calcul sur ma donnée et du coup, vu que je n'aurai pas copié en fait la donnée, ce que je vais faire, c'est que je vais pouvoir garder une trace très claire dans la blockchain qui va dire à telle heure, tel jour, tel acount à demander à accéder à cette donnée là? Et je lui ai donné accès. Mais je ne vais pas juste donner accès. Il fait ce qu'il veut. Je lui ai donné accès via ce programme là qui fait exactement ça. Ou potentiellement, on a fait un audit sur ce programme et on est d'accord avec ce qu'il fait et c'est tout. Et à la fin, à la fin de l'exécution, il n'a plus accès, en fait, parce qu'il a soit envoyé son programme sur mon infrastructure et du coup, après, je lui permet pas d'aller plus loin. Soit je reencrypt m'adonner d'une autre manière si j'ai vraiment pas confiance. Et dans ce cas là bah, la donnée est différente de ce que lui a eu accès. Donc vraiment, je pense que je pense qu'on peut arriver à des choses assez élaborées, en fait, en terme de gouvernance. » Tim Richmond : « I mean, this is, again, a major benefit. So as much as anonymization of the source of data is possible, if you want to know the source of the data and you want to know and you make that aware, you make yourself aware, look, this is me, this is my transaction, it is entirely possible to trace everything that happened on the block chain. It is entirely immutable. So if the goal is to get to be, how far did it get in this iteration of the algorithm? And so you leave it until it achieves its goal. And then all of the interactive data that it's produced is available. Right. So if you did that on the block chain, then you've basically you've created a situation where all everything would be immutably. So it would be permanent. I mean, to do this, you can do this on your machine at home ».
Data quality, availability and provenance	Ahmed Banafa : « The medical and health sector is heavily regulated, right. Because there is a protection for the patient, you know, data, for example, here in the United States, we have something called HEPA, which is a very tough regulation, which is you cannot share the information. You do all this and this and so. But if you can have that blockchain and the hospital understand that this is a safe data, nobody can change it. And the Ministry of

Health understand that one. They will feel more comfortable saving their data in the blockchain instead of saying, how can we protect this data? The regulation will be less in this case. Why? Because it is safe. It is encrypted. Now, you're going to have more, you know, pure data and this data will be much available for you. Why? Because I feel safe leaving my data with you. Before you have multiple data, SAP is one of them. You talk about Oracle, one of them, the other companies with a different protection for database. But this is protected and that will be much easier for you to use it. »

« That is where blockchain can save time. And time is helpful for the A.I. because you can increase, as you said, the quantity of the data that's going to be pure. It's going to be quality data. And also you're going to make it faster for AI to go through the data instead of spending all their time to clean it. Now, you can say this is a good data. I do not have to deal with anything other than that »

« A.I. is a software, blockchain is a software, and it's using the smart contract again, you can extract this data and have it in tables and those tables can be used by, you know, by AI is an easy way for you. There's an interface almost between the two. Because both of them are software so they can talk to each other very easily»«You talk about the blockchain, talking about immutable records, the data cannot be change. We can trust it. It's transparent, is accessible for everybody. You look at the AI, AI will help us on getting the insight from this data. And just generally speaking, if for the AI itself, which is built on machine learning and deep learning and statistics and all the different mathematical models, the very important concept of garbage in garbage out in statistic, which is if you have a bad data, you enter this one area, you feed this one to this program. And the results will be that something called garbage in, garbage out is a well-known concept in statistic. Blockchain will help with something like this by saying the data itself, which is from hospitals or from supply chain, once you store it on the blockchain, nobody can change it. So technically speaking, you can trust this data. Why? Because you know it's a blockchain, it's not a database. Somebody will give it to you and you can ask what's the integrity of the data? And then you take this data and you clean it. You go with the clinic and then you process it. If somebody told you this is came from blockchain system, you going to say, OK, no, I can trust this data. I know that nobody modifies it, otherwise I can use it without any problem. This is one big advantage to the other one. » « I have a specific example about that, because it's the relationship between the data. I mean, Blockchain is not real time. It's it is something called almost real time. There are systems that go up to 15000 transactions per second. Blockchain, at this stage, it is not a real time when you can just extract the information right away from a car or from Camera or and then process it. It's more like it's a database which store the data and then the machine learning will come and take this data and study it and have a model out of this. It's exactly like if you are in a hospital and then by the end of the day, all the data will be stored and the blockchain and it's all available and then AI will go and study this one and see if there is an increase in the cases of this or increase of case of this one. it can give you this kind of analysis. So real time processing is not there yet, which is right on the spot like Dashboard. You can get this information because of the nature of the blockchain itself. »

Daniel Yasri : « La blockchain peut absolument, absolument, aider l'IA en termes de big data. La triangulaire big data – blockchain – AI c'est vraiment ce qui fait que la blockchain et l'AI peuvent travailler ensemble et sont une technologie d'avenir. Ça va te permettre de certifier tes données, d'avoir un registre énorme qui peut être trustworthy, ou tu n'as pas de question de confiance à te poser car tout est tracée, signé, tout est oracler comme on avait parlé. Si tu as des données qualitatives, tu fais du machine learning de plus haut niveau et beaucoup plus rapidement. Deuxièmement, la blockchain permet aussi, grâce à des métadonnées de facilement agencer, l'AI sait donc facilement ou chercher. (...) les avantages de la blockchain, tu augmentes la qualité et l'intégrité de tes données, et la provenance, la sécurité, la transparence. » « Tu as des données qui arrivent, tu veux qu'elles soient sécurisées, transparentes, timestamper, de qualité, savoir d'où elles viennent, assurer leur provenance, tout ça, la blockchain répond. Donc vraiment, les

interactions IA-Blockchain, c'est je plug du data qui est qualitatif. C'est énorme en fait. Les gens ne s'en rendent pas compte. Le ML c'est dépendant que de ce que tu lui donnes. »
 « Tu peux t'assurer des données qualitatives avec des labels par exemple, comme si tu dis : oui, regarder, je vous assure, ça vient de tel truc, c'est tel hash, ça vient de là etc. Et mon robot, il est entraîné qu'avec des datas de qualités. Je peux vous dire, je vous assure ce sont tous des patients diabétiques de type 2 et je vous l'assure. Personne ne peut faire ça aujourd'hui. Personne ne peut vérifier que ce soit la vérité. »

Joan Van Loon : « Blockchain is not what will control if people will give access and if you have access. But once the access is given, then blockchain can manage the process behind it and making sure that the new data that comes in comes from the right source and is validated then and whatsoever. But for instance, take the Belgian situation here in Belgium, if you look at healthcare data, this is basically, this is in the hospital, this is where the general practitioner, some of the data is with the insurance, some of the data is with private insurers and whatever. So the data is really spread in different silos. So blockchain as such will not open those silos. But if the owners of the silos decide to give access to their data and to open up their data for everyone, then block chain indeed could be an enabler for them to make sure that they know who will use their data, what they're used for and where they're going to. So it basically enables, it gives a more secure and safe and controlled environment to be able to open your data. But of course, if only two people or three people or three companies decide to create a blockchain, the data will still be remaining for those three companies. If there are 100 companies willing to do that, then of course, you have a different story. So what we see, for instance, we have build a block chain for banking, the wheat trade. I do not know if you heard about that, but this is about banks wanting to share their information on a blockchain platform. If you do that with two banks and that works fine for the two banks. But the major advantage is if you can do that with all the banks in Belgium. So blockchain again helped them to say, OK, we have now a secure ledger, a secure infrastructure where all the operations and all the data are exchanged but also controlled. And it depends on who has access to which data and what. So by having the blockchain, more banks are interested to step into the process because they know the process is secure. So it's the same with health care. »

Julian Fifield : « So I think because you're collecting potentially truthful information, you can construct dashboards which make access to reporting and anomalous events and other things easier. So I think actually done right. You can improve access to data. You do not need to go through the linear old loops that you do with old traditional databases, trying to get make sense of data coming up from Oracle database. This is really hard work. Really hard work so the machine can straighten out and all that and do automated reports, automated anomaly, check an automated look at this anomaly or look at this report in real time, very, very fast. Over and above traditional database methods. » « Blockchain's primary ability and potentially if it is done right, is to capture accurate information and then effectively digitize it in a non-tamper proof way, which means if you got some accurate, truthful data, which cannot be tampered with, you can then start to run interesting artificial intelligence on top of it. So that could be all sorts of things, digital identity, you, the person who is in the system, is the right person. So you've actually got the right person and therefore you can trust the data about it. »

Bill Inman : « Absolutely, I'm talking to a company that is creating a platform to easily connect your data into a blockchain based AI data network. It doesn't have anything to do with the actual algorithms. It's just the information. So it absolutely can, because you know, there's a lot of data around the world, whether it's at a mid-sized company or an enterprise or some other type of organization or even individuals. They do not know how to monetize their data, how to get that out there into the field. So having a platform, a block based platform that creates security and accessibility without threatening the anonymity of the data or making all the data public is a great way to leverage blockchain for AI. »

Hasen Kapasi : « If a company says, OK, I have my algorithm, it provides you all the insights, that's fine. We can actually believe it's not futurist today, but why other companies would share the data with you? Because in healthcare sector is a sector, you know, where data is goal basically whatever the research they're doing, you know, in terms of clinical trials or in terms of any of the medicine research or any other stuff. And nobody shares any data with you because that's their IP. And in that environment, if you say, OK, I want to have an AI algorithm, AI platform and you do not have that data, and that's where blockchain will come into play, like, OK, blockchain will make sure that each and every parts basically gets in line and everybody has the same transparency and trust on that system that we agreed upon will be followed on that platform. So, again, you know, I would like to highlight here that blockchain is a team sport. It comes into play when there are multiple companies, multiple meanings, more than four. I'm not directly relating to it, you know, but I need to share the data with them so that, we have transparency enough to get the insights what is needed. »

Robert Miller : « Certainly you can use a blockchain to record data permission, your AI could click on a couple of buttons and then you're setting boundaries on how we want our data to be used. And there could be an immutable record of that that could then be referred to as like an audit log, perhaps, and that every time someone is accesses your information and uses it for some purpose, you could record that within the blockchain to give people the ability to go back and look and say, here's who had access to my data, at what time, for what purposes. And I think that that would go a long way to facilitating trust. And ultimately, more data sharing and usage. »

Natalia Monteiro : « Yes, because blockchain allows access to silos that before, would have never. So actually improving your AI model by the amount of information you are feeding in. »

Jonathan Passerat : « Pas seule. La blockchain, c'est une condition nécessaire, mais pas suffisante dans ce cadre, parce que, comme je le disais en fait, la blockchain seule ne te permet pas de sortir de cette boucle de data sharing. Et du coup, tous les problèmes que tu as évoqués avant sont aussi liés à la duplication de données, à la gouvernance sur ces données, en fait. A partir du moment où tu dupliques ta donné, tu perds en fait toute possibilité de gouvernance. Tu peux dire dans ton application, non, j'arrête de consentir à ce que mes données soient utilisées pour train cette AI. Mais la donné elle a déjà été copiée. Tu n'as aucun moyen de prouver que ta donnée a été supprimée. Aucun moyen. Et ça, ça, c'est dans le GDPR, Tu as le right to be forgotten. Le right to be forgotten, à l'heure d'aujourd'hui, c'est remplir un formulaire. Et voilà, on te dit OK, c'est fait, mais tu ne peux pas le prouver. »

Tim Richmond : « Well, blockchain and AI, It's like a marriage made in heaven. Right. These two things, they they facilitate each other in amazing ways. So I've just mentioned, the anonymization of data. » « If we could connect everything together via lot. Then all of these devices can share the data into what's called big data and big data is what bubbles out of lot. And so it is it is a massive resource of data that previously would be impossible for humans to recognize any kind of relevancy between data sets. AI, on the other hand, is fantastic at being able to see interconnections between different things. So not only will your computational device that you use at home, your laptop, your computer, your phone, not require consistent upgrades of physical hardware because it'll draw in processing from the cloud. Right. So it will pipe in computational power. It'll also be able to share into big data all of the data that's there and blockchain and A.I. obviously, when you get to the point where you've got this massive data set. You need some way for A.I. to be able to interconnect these devices, to be able to interconnect and blockchain style technology is ideal for facilitating these kinds of transactions. OK, so the data is being ported continuously and consistently. In fact, our annual data that is increasing exponentially in line with the amount of data we produce each year is is increasing in line exponentially with our technology »

	Hubert Ridolphi : « Sur la transparence, sur la sécurité ou sur le partage sécurisé des données, la blockchain peut apporter. Maintenant, sur la qualité des données, la donnée elle-même, non. Mais la source des données, oui. La blockchain peut apporter du trust, tant qu'elle soit publique et auditable par tout le monde. » « Mais là où la blockchain peut interférer avec l'intelligence artificielle, c'est que l'intelligence artificielle va avoir besoin de set de données longitudinales, c'est à dire dans le temps par rapport aux données de santé. Et ça, c'est important quand vous voulez faire de l'integrated care, par exemple, vous voulez soigner quelqu'un, mais voulez savoir qu'à 20 ans il a fait une appendicite, que son grand père a fait un cancer de la prostate, que ceci, que cela, là vous allez pouvoir faire de l'integrated care. Donc il va vous falloir de la donnée de qualité par rapport à l'historique d'un patient. Et dans le temps, je parlais du grand-père exprès pour l'illustrer. Et donc là, le patient va devoir partager ses données. Et la blockchain peut apporter le trust pour qu'il partage ces données et pour que l'intelligence artificielle derrière puisse l'exploiter? Mais c'est là où je vois le lien » « les données anonymisées a beaucoup moins de valeur non anonymisées. Si vous avez besoin de revenir aux patients, si vous traitez des données anonymes ou si vous agissez à partir de données anonymisées, vous ne pouvez pas revenir au patient. Et c'est pour ça que la gestion du consentement est très importante. La gestion dynamique, qui peut être retirée à tout moment, est importante dans le temps pour apporter un résultat de qualité par rapport à une intelligence artificielle. Pour l'entraînement de l'intelligence artificielle, ça peut se faire à partir de données anonymisée bien entendu, c'est deux phases de l'intelligence artificielle. »
Type of blockchain	Ahmed Banafa : « You have to distinguish between two things that are types of blockchain that is public, there is private and there's hybrid. Private, everybody knows everybody. It's basically, you know who is this computer, etc, it's easy for you to find. You know, I work with some of the companies here in the Silicon Valley, like Thermo Fisher. And I was explaining to them that you can have five thousand of your employees and you can assign them, they say, and you know who they are. So their identity is not going to be exposed. But if it's public, like Bitcoin and ethereum, you do not know that. Say you have like twenty thousand computers. Who is that person? There is hybrid. Hybrid is a mix of both. You can have some of the information on a private blockchain for you and you can have it on the public where people can access it without knowing who is that person » « Private is always the case. Just make sure that the number of the nodes is big. That's the whole thing » Daniel Yasri : « Il y a différents types de blockchain, comme tu le sais à mon avis, les blockchain publiques, Bitcoin, Ethereum, les blockchain semi-publique sur lesquelles, par exemple, il faut s'inscrire pour avoir une clé privée et avoir le droit d'être dessus. Donc, ça veut dire que là, tu mets des informations à toi. C'est comme s'inscrire sur un site internet, mais tu peux ensuite avoir le droit d'avoir accès à cette blockchain alors que le bitcoin tout le monde peut y accéder, tu n'as pas besoin d'avoir accès, tu n'as pas de zone d'accès, tout simplement. Puis tu as les blockchain privée qui demande vraiment de faire partie d'une entreprise, etc. » « C'est une blockchain privé/public. Public dans le sens que certain pourrait consulter ton dossier. Il faudra être oracle pour le consulter, tu n'as pas envie que tout le monde consulte ton dossier médical. C'est semi-public, semi-privé. On appelle ça vraiment une blockchain de consortiums. Si vraiment tu cherches le terme, c'est vraiment ça. C'est entre privé et public et c'est vraiment ce qui s'applique dans le domaine de la santé. Pour moi, le mieux. Mais la blockchain, c'est vraiment très compliqué. Et c'est compliqué à faire aussi. C'est compliqué à coder, à appliquer, à faire. Moi tout mon travail de consultant consiste à mettre ne lien ce que veulent les professionnels de santé avec les développeurs qui souvent ne comprennent rien l'un à l'autre. » Joan Van Loon : « It always starts from a consortium perspective and certainly in health care. And that's also the reason why today you do not find many blockchain in healthcare »

Julian Fifiield : « That's right, that's correct. And I work in private projects primarily. My work is mostly private profit. And that's because, there's a number of reasons. The private blockchain are, when you are dealing with multiple stakeholders in a value chain, they often do not trust each other (...) there is a kind of collaborative governance structure, which means people do not have to trust each other because they have agreed the rules of exchange between them. And the private chain means only those who have committed can join in. So all the data is not public. It is contained within the value chain. And everybody agreed the rules. So they trust it. So they trust their bit of it over the top. And the machine enforces the trust, trustworthy behavior. »

Hasen Kapasi : « If you really want to use that data, it has to be a public blockchain so everybody can actually participate, first of all, and actually be trusted. If you say, OK, now that is a private blockchain own by ten companies, nobody is willing to share its data. That is why now there are two phases of it. One is really getting the data, collect data. And then also this trust part, because that is how you actually say, OK, this is a public platform where everybody can upload the data anonymously and we can use it for the insights. That's why people are really using and going towards Ethereum based platform like US to really develop the concepts for the gene therapy and so on. And in terms of private blockchain, I think, you have a kind of ecosystem developed by multiple companies and it's like a separate ecosystem. »

Robert Miller : « I prefer public blockchains but this is not a popular opinion. Most people say private. Public blockchains are more secure and they have like a very long track record to them. So there are billions of dollars on Ethereum and there has been there for many years. So I know that Ethereum is not going anywhere and no single party owns it or controls it. So this is very useful for a lot of things. There are things that I wrote on the Bitcoin blockchain in 2012 that are still there, which is cool, and there will always be there. And you know in the context of health care, you're not going to be putting sensitive information on chain, whether it's private or public, it doesn't really matter. So if the information is going to be putting on a blockchain, it's just like a hash of data or something. And there's no real reason to not put it on a public blockchain. I guess the real reason to do it would be that enterprises are not comfortable working with public blockchain and they prefer private. » « It can be a problem. But the kind of things that you would be using a blockchain for with AI, I do not know if you necessarily need a lot of transactions. If you're using a blockchain to help train an AI, it's probably to record what you're doing, what data you're accessing and when. And it is like a single transaction for one training around. Maybe in the next round of training is another transaction and then you record the accuracy of each round. Ethereum can take 12 transactions for a second. Something like that. And what I just laid out wouldn't be more than 12 transactions for a second. I think it would probably be like one or two max or something like that, maybe less. And the other thing that people always talk about is the cost of using a public blockchain. And this is also true but having worked with big enterprises, it takes a lot of money to stand up a private cloud and then run a node in it and have somebody watching the infrastructure to license for all the software that's involved in it. There's concrete costs associated with that as well. And I tend to think that the cost of using a public blockchain will be less than the cost of running your own. So, yeah, I do not think speed will be a problem and I'm not very worried about cost either. »

Natalia Monteiro : « it needs to be private, but it needs to be with enough of the participants. The way I see it is that they're running parallel until one of them proves to be superior than other. » « And it's a 10-year-old industry, which seems a long time. But on the other hand, considering how revolutionary it is, I think it's quite young yet. »

Jonathan Passerat : « Une blockchain privée, C'est une base de données, c'est une base de données distribuée. C'est bien pour faire des tests, c'est bien pour donner de la confiance entre certaines entreprises, mais dans la plupart des cas, si tu pousse un peu, tu vas te rendre compte que tu pourrais le faire, que tu pourrais implémenter ton use case avec autre chose que la blockchain. Maintenant, quand tu passes sur une blockchain publique,

	le côté, le côté imutables en fait. Le fait que tu puisses pas modifier, que se soit open only et le fait qu'il soit très difficile de tromper le consensus fait que tu a confiance en une source de données publiques que tu n'avais pas avant. C'est vraiment cet aspect de chaine publique moi qui je trouve, fait la différence avec ce qu'on avait avant. « Privée ou public pour HC ? Public. La raison pour moi que les blockchains privées, je ne dis pas que je m'en sers pas, on s'en sert assez bien. Mais ça ne doit pas être la finalité. Si la finalité de ton réseau, c'est de mettre en place une blockchain privée, je pense que tu pourrais le faire autrement. » « Quand tu es sur un réseau privé, tu vas te mettre plus de contraintes qu'autre chose. Et pour des taux de transactions beaucoup plus faibles que sur une vraie base de données distribuées. » Tim Richmond : « For health care specifically, you've got two types of requirements here. You've got the need to secure privacy, I think is the primary key. And then there's the need for access to data. So what blockchain does is it enables you, although all transactions are entirely immutable so that they're permanent, that you can trace everything. It also has a fantastic ability to anonymize data. So you're able to obtain vast data sets while maintaining someone's privacy. Right. However, obviously it depends on what the use case is. So, for example, if it's for research, you want access to as much data as wider data and deeper data as you can get. Blockchain is ideal for this because it allows the collection of data from sources from people that perhaps wouldn't normally want to give up their data because it allows them to maintain that privacy. However, if there is ever a connection between the person and the data, it is then immutable. So there was recently a whole thing about the right to be forgotten. And GDPR in general, it's a legislation which is out of date before it even came in because you can't remove data from the blockchain. All right. So yeah, so blockchain is also a great way of maintaining data, whereas previously it would have been lost, it is another great advantage. And for that, an internal private blockchain within a hospital environment is a fantastic route to being able to tie together, you know, previously unconnected data in a way which is permanent. » Hubert Ridolphi : « Je dirai sans équivoque, la public blockchain car à partir du moment où tout le monde peut vérifier, seule la public blockchain va être encore plus trusté. Bien sûr qu'on peut truster une blockchain privée. Mais la blockchain publique apporte véritablement le trust. Maintenant, la problématique derrière le développement d'une blockchain publique c'est le coût, ça coûte très cher. Ça peut coûter des milliers. Si ce sont les utilisateurs qui partagent leurs données médicales qui est important, à ce moment-là, vous avez tout intérêt à avoir une blockchain publique. Si c'est pour une application pour une maladie dans un système, à ce moment-là les simples accords directs garantissant les consentements dynamique etc n'a pas besoin de faire appel à la blockchain. Le coût dépend donc de votre modèle et de votre business model. »
Issues from merging AI and blockchain	Ahmed Banafa : « There is something around it because data is data by the end, data is you can modify it by the end of the day. But if we have this the same standard across the board for everybody to use the same format of the data, it's easy for me just exported and imported from those systems and run it. But now I have to do multiple steps. I'll be OK with IBM. But now if I take this one from Amazon, I have to do a few steps. So it's going to be compatible with what I'm having to. So you adding some difficulties to the process (...) but it's not a big challenge for one reason, blockchain it's still small. And the player number one in blockchain is IBM when it comes to the private production. So they almost control the market in this part. It's going to be a future problem when we talk about the different systems talking to each other, that's going to be a problem. And that's why we need to get the IEEE, the organization, the Institute of Electrical Electronic Engineers, the one that brought us the wifi standards to bring some standards to the blockchain so the data itself, it doesn't matter who is processing the data, the result is the same. » « Well, just finding the right people. That's another problem you have to think about. How can I find the right people? The skill is expensive. Blockchain is expensive. It's not cheap. That's why you have to make a decision what kind of data you're going to put there. That's why

only big companies and government and organizations, international organizations, they can offer that one but small company, they do not need it. »

Daniel Yasri : Il y a déjà la limite à l'adoption de la blockchain dont on a parlé avant, le coût, la difficulté, la complexité de la chose. Et après, ça va être encore plus un défis technologique de lier les deux. Que ce soit au niveau du codage, du cadre légal que ça va impliquer, de la gestion des données, de la gestion de l'erreur, tout ça ça va être des limites qui vont se poser. Et aussi, les compétences qu'il faudra que les gens aient ou pas. D'ailleurs, si on arrive à des niveaux de simplification assez avancer pour que ce soit utiliser par mr tout le monde ou au moins des gens formés, quel niveau de formation il faudrait y avoir »

« Les 3 gros problèmes sont la vitesse de traitement, coût et complexité. Dans la complexité, il y a la complexité scientifique, et théorique. Mais au début, la blockchain et l'IA ou la blockchain tout court, ou l'IA tout court ce sera compliqué. Si tu regardes un blockchain explorer, les gens n'y comprennent rien. Mais peut-être qu'un jour se sera facile. Ca c'est au niveau pratique, après il faudra aussi mettre en pratique, il faudra avoir les connaissances pour mettre en pratique, des humains, des ingénieurs qui arriveront à faire fonctionner les deux en même temps. » « , tu code ce que tu veux dans une blockchain. Si tu veux faire une blockchain ultra rapide, tu crée une blockchain ultra rapide, mais il faut juste que tu l'adaptes à ton use case. » « il faut à la base que ta blockchain elle soit conçue pour ça. La scalability elle dépend de ta blockchain » » Le problème c'est pas est ce que la blockchain est scalable c'est plutôt comment rendre scalable ma blockchain pour répondre à mon use case qui est l'intelligence artificielle. »

Joan Van Loon : « the main the main issue is about, like I said, you first need to process you first need the different parties to agree on how to work together. And that is the main issue, certainly in health care and certainly in Belgium. So today, all this data is still distributed, then spread and is not being shared. So the accessibility to the data and then the next step is, of course, checking the quality of the data. Somebody needs to start and own that process. And this is something which is not happening today. So as long as there is no will to share data, to set up a blockchain and of course, the blockchain will have will have no value. »

Jonathan Passerat : « c'est difficile pour deux raisons. Il y a les défis techniques, mais il y a des difficultés d'adoption par les utilisateurs aussi »

Bill Inman : « It's not proven that enterprises want to store their data in the blockchain for AI. It's not proven that enterprises want to bring out bring in third party AI so without knowing exactly decentralised that is, without knowing exactly how they were created. » « decentralized isn't proven that the companies want to share their data yet through a decentralized model. » « Many of the decision makers, even up to the CIO level that businesses want to and are comfortable working with IBM, Amazon, you know, Tencent or whatever the case may be in the various countries because if they make a decision on a small provider, their job could be in jeopardy. They're quite often much better going with this, with centralized because basically Amazon is. » « Overconnectivity, you know, right now to in order to be decentralized, you have to have an API and an API of APIs to be able to take your enterprise and plug it into decentralized A.I. You know, there are forty-five hundred artificial intelligence companies that have been funded with 80 billion dollars since 2014. That means there's forty-five hundred different solutions out there that a CEO needs to know how to navigate and leverage. So until there's a real ecosystem of decentralized AI that can be brought together, once we know the problem, they're not easy to access. That's part of what we're doing, a singularity studio, but we're still young. So being able to find that qualify decentralized AI solutions and then bring them in securely into the enterprise is not as easy as just going to Microsoft, saying, I'm going to use Azure and what you have available ».

Hasen Kapasi : « I would say infrastructure wise, it's now feasible. Most of the people think scalability is one of the biggest issue. But if you really want to develop it, I think that it is possible today. You heard the computational power, which is completely solved in the

solutions like Hyperledger. But people do not understand it. So people have this matter on scalability like, okay, how can I scale to my big ten thousand people and so on. It's easily possible. There are companies like ConsenSys and there are many other ones which can do that. So I do not see this as a problem. It's not smooth like SAP a system. I would say, there are some ups and downs, but there is already a solution out there in the market because at the moment you need to have a stitch around that solution. So you have one piece of technology, you have another piece of technology, and you need to stitch those two technologies. So that is where the programming effort comes. It's not available on the shelf at the moment. And that's why people think, yeah, OK, this is the problem, but that's not the challenge. You can do it. But you need to have that vision and you need to have that understanding. ».

« First and foremost awareness and education are issues. When we speak to any specific domain expert, they have their own expertise in that. And normally they do not understand the full picture. As I mentioned, blockchain is a team sport and you need to understand the complete endurance cycle. People just think about their specific business. And they do not really understand. And that is why consultants play a major role at the moment because we've been there as an orchestrator. We understand suppliers, we understand buyers, we understand the manufacturers. And then we say, OK, this is the full picture. »

« The companies need to think about how the blockchain can be interoperable. It's easy to talk and connect and interoperate between this because, private blockchain, you can also do it for sure. It's the same. Public to public, Public to private, It's all the same. But I think public is more rich on that one. There are multiple solutions like Bullecourt or Chainlink. You know, they are already out there and there are standards out there. So I think it is already being solved. It's not a bottleneck at the moment anymore. »

Robert Miller : « It's slow and the development is bad. I do all this stuff on the side like actual coding, and it's just not good today compared to other types of developer tooling. You can't store that much Data on a blockchain. You can't delete things, which means that you can't touch any sensitive personal information, which in health care rules are basically all data » « I think the principal problem is that it's very difficult to do things on a blockchain if what you're acting on is not native to a blockchain. That makes sense, so it's already pretty hard to work with Ethereum or a cryptocurrency or something on a blockchain. It's much more difficult to work with things that are off chain, which is inherently all data, basically, and doing so you need like intermediaries that can take data that are off chain and put them on chain and then maybe those are trusted third parties. So it introduces a lot of problems just working with things that are off chain using a blockchain. » « more developers are needed too, I think that's the problem. And then a lot of this stuff, people do not really know how to make money out of it. Like the business model for a lot of this is very uncertain and unsustainable ». « 51% attacks : at least with public blockchain, it is not a problem in small private networks, it is ».

Tim : « So its speed. So at the moment we only have like very few algorithms on there and there isn't a great deal of usage. AI, and blockchain is fantastic. It marries perfectly together, but it's the speed of the transactions and the volume of transactions being very slow and very small that is holding everything back. And if we can increase the speed of transactions, then obviously, more transactions can happen at once. And so more people would use AI and so it would take off. The other challenge is interconnectivity. So we have all of these blockchains. Right. But they're self-contained within their own environment, so what's needed, there are islands of brilliance. And the problem is that they're then not able to interconnect properly. There are some solutions to this, but every time you create a solution to this, it becomes a centralized system. And the third issue is, I mentioned before the ontology of AI algorithms themselves, so we want to be able to have AI able to interconnect with another AI on our own platform. That's what we've designed it for. But we want them to also interconnect with an AI, which has been designed on another platform. Yeah. And so we create what's called an ecosystem of ecosystems. So it's like a

	massive structure of interconnectivity and cooperation. But what's holding it all back is the scalability of blockchain. » « The primary thing is, is being able to maintain the decentralization of the system. It's kind of pointless to tie together these ecosystems if there's a central place that's happening. So what what I personally believe needs to happen is there needs to be a kind of mechanism that sits in front of the blockchain that is part of the blockchain, and that can lock up tokens or or actual coins of one side and release on the other. And then it's not owned by anybody. It's just a protocol. And therefore that would work. But this introduces another resource or another obstacle for the overall system to get over and will slow everything down again. So it's the speed and being able to interconnect. I think quantum cryptography can help with this by increasing the overall speed. But I also think that the structure of blockchain needs to change, OK » Philippe Coucke : « Mais encore une fois, la blockchain sera là pour dire que les données qui sont fournies par les systèmes, que ce soit humain ou machine, proviennent bien du bon individu ou de la bonne machine. Et après, ces données seront analysées par une intelligence artificielle » « J'ai un peu de mal avec les comment dire, le mélange un peu des deux, c'est très comment dit disruptifs. Mais il y a des choses qui sont, dans la recherche biomédicale, qui sont utilisées je pense avec une des collaborations entre des systèmes trustés grâce à la blockchain et après analyser avec intelligence artificielle. »
Usefulness of the integration and Job's performance enhancement	Ahmed Banafa : « Yes. » Daniel Yasri : « Oui et non. Si le use case est fit. Si la blockchain sert à son truc. Donc si la blockchain est utilisée pour ce qu'elle est. Si c'est bien utilisé. » Joan Van Loon : « I do not think it will by definition improve the user's job performance. I think it will improve the developer's job performance and the ones developing and designing the AI applications. So the end user is not interested in the process. So as long as the answer is quick and is there, it's not the end user that the performance will increase by having auditability or hold data and by having all the quality of the data, they just want the right answer at the right time. » Kapasi : « I cannot provide you any more information. But that is exactly you know, that's why I mentioned you that this year. And I was actually very surprised to see those kind of projects coming from the pharma companies. And they say, hey, we've done this and those companies are already bet on this. So, you know, it's not like you're talking about some research paper or any specific. They already filed patents in the US and Europe. So it's a patent now. So this is not some consulting project anymore. It's really something very, very tangible. » Philippe Coucke : « La réponse est indéniablement oui. C'est indispensable. Comment peut on gérer aujourd'hui la santé publique sans avoir accès aux données? Aujourd'hui, nous n'avons pas les données. Nous gérons la santé publique sans avoir accès aux données. » Bill Inman : « The answer is yes, if the AI solves the problem for the company, then that should provide insights to be able to drive productivity. That's why they use it, I think. But they need to pick the right AI, integrating it the right way with missing points on the person or other AI agents they could use. You know, a lot of mid-sized companies can't afford to use Azure or EWS solutions and their solutions are too expensive. So having Blockchain on a decentralized level, it helps the market because it drives down the costs. Different AI that aren't behind or attached to a platform that could be costly can't be leveraged. So it certainly has the opportunity to make everything more accessible because of cost. Now, once AI decentralization matures and is very simple plug and play model and there's this API of APIs to bring together all these different APIs of all these agents, connect them, overlap them, it will be great. That's the plan, it is to orchestrate multiple AIs, to do new things on a real time basis. Then it will be more powerful than the platforms because the platforms are limited by the security of the governance of their enterprise, the Amazons, Microsoft and so forth. So it will be more accessible. But Enterprise, decentralized A.I. is not there yet. It's in early phases as all AI such as IPO is an example of a centralized A.I. and that took many years for it to become useful to governments with very basic insights on existing data. We're in the very early phases of decentralized A.I.

	But it will make AI much more accessible and cheaper once we get there. We're not there yet». Richmohd : «One of the biggest challenges in medicine is being able to accurately process large amounts of data to obtain important diagnosis in the fastest time possible while still protecting the privacy rights of the patients. AI and blockchain combines are ideally suited to both speed up the diagnosis process by identifying key markers for disease in very large data sets in record times while still maintaining the anonymity of the data origin. Using Machine learning to increase the effectiveness of diagnosis AI models by feeding it very large and continuously growing data can yield incredible results such as identifying patients with a pre disposition of a condition pre-disease, allowing medical professionals to treat the patient much earlier, possibly even avoiding the onset of the condition in the first place, saving lives and reducing the cost burden on medical institutions». Jonathan Passerat : « Peut être pas tout de suite, j'espère, mais pas immédiatement. Pas à pas avec ce qui est sur le marché à l'heure actuelle». Hubert Ridolphi: «Je suis partiellement d'accord, d'un point de vue technique ce n'est pas incompatible, c'est une complémentarité. Ça, c'est clair. Mais je pense que oui, il va y avoir des choses qui vont utiliser la blockchain mais on ne le saura même pas. Ce sera un tool ou on vous dira que c'est garanti par un système de blockchain qui permet justement de prévenir lors d'audit que ça a été ou pas modifié et donc qu'il va éventuellement avertir l'intelligence artificielle comme quoi elle ne doit pas prendre cette décision parce que c'est les questions qui deviennent ou des données qui viennent d'une personne non trustée par le système». Robert Miller : « Doctors and patients would benefit at the end. But the first sort of users who would benefit from it are like informatics', people who work with health data and our dedicated staff to that purpose within our hospital today. Those are the people that benefit immediately. And then down the line, a couple of years later, with more adoption, patients and physicians will benefit more.» « I think it is immediately useful and in the more distant future, it will offer the possibility of creating algorithms and technological services that are totally different and have a better relationship with users than today».
Implementation difficulty and difficulty to use	Ahmed Banafa : «Over time, yes, because we're going to improve the user experience and user interface, it's going to be much easier for us in the future». Daniel Yasri : « Il faut juste par contre qu'ils se mettent dans la blockchain, qu'ils acceptent de faire le pas ou d'investir dans des gens qui développent la blockchain. » « les développeurs de blockchain qui n'ont aucune connaissance médicale ou pharmaceutique et qui du coup doivent coder des choses qu'ils ne connaissent pas. Et c'est là où l'interface elle est un peu compliquée » « La blockchain, ça fait peur aux gens. Tu n'as pas besoin de parler de la blockchain. » « la première erreur qu'on a fait, en rentrant dans ce milieu-là c'est qu'on a beaucoup parlé blockchain et que ça a fait peur aux gens alors que c'est juste une technologie. » « pour arriver à ça, on doit faire en sorte de faire disparaître la blockchain en tant que mot, qu'entité, que les gens ne comprennent pas. (...) La blockchain c'est pareil. Un jour les gens vont savoir que c'est un registre, transparent, c'est sécurisé, c'est tout. » « Non, car ça coûte de l'argent et des connaissances » Richmond : «Technological advance is in essence an evolutionary process and much of the infrastructure to deliver AI medicare already exists inside healthcare institutions. What's needed to make the leap to using AI and Blockchain not just in the medicare sector but globally is an increase in education toward how one could apply the technology. Sadly there are so few specific AI developers in the world, and many of these developers work for large organisations. However, this is changing and through decentralised technologies the power held by the tech oligopoly is being decimated outward through the use of blockchain type technologies. In the not too distant future however, AI itself will be able to program effectively and one may not need to possess a high degree of technical knowledge to employ or roll out effective systems».

	Julian Fifiield : « Near time, it won't be easy to use. But over time it will become easier to use because the machine, instead of relying on analog models of interactions with machines and databases and stuff, the machine will do a lot of the heavy lifting and will do the work for you so it will become easier to use over time. » « And this is the same in all health care systems. It's not an innovation space, it's not an innovation space at all. » Joan Van loon : «At technology wise, yes, process wise and legal wise in Belgium, no». Philippe Coucké : «Ca va être relativement difficile à mettre en place parce que, ce n'est pas une question de technique, la technique suivra, c'est une question de culture, organisation et culture, politique et culture des utilisateurs et changer une culture c'est toujours plus compliqué. Surtout dans le système de la santé qui est fort derrière en terme d'adoption. 30 à 40 ans.(...) : Je pense que ça passe par l'éducation des futures générations des soignant. Ils n'entendent pas parler de ces technologies pendant tout leur curriculum. » Kapasi : « Over the last three years it was more initially educating the client. So what is blockchain, the ideas and so on. Last year was more or less sort of project request coming from a lot of the use cases. How does this work? What are the type of blockchains,... And all those things. And this year is really how can we implement this along with different other technologies like AI analytics, IoT and so on, and how can we actually go to the market.» « First and foremost awareness and education are issues. When we speak to any specific domain expert, they have their own expertise in that. And normally they do not understand the full picture. As I mentioned, blockchain is a team sport and you need to understand the complete endurance cycle. People just think about their specific business. And they do not really understand. And that is why consultants play a major role at the moment because we've been there as an orchestrator. We understand suppliers, we understand buyers, we understand the manufacturers. And then we say, OK, this is the full picture. ». Bill Inman : «It will be very easy. It has to be very easy to use and implement. Simply connect your information source via API into decentralized A.I. Once you're there, you need to know your problem, speak a problem, type a problem into the GUI and then behind the scenes, this is the vision, AI orchestrates all of the different AIs together into one solution, like a Lego set, it brings AI actually pulls together based upon the problem all the different AI and solves it without any human intervention, any human code. That's the ease of use that we need to get to. » « Singularity already has blockchain for incentivization for A.I. That's already built and you can connect an AI into our platform, so it's already done, actually. So I wouldn't say it's complicated, but in order to make it easier to use, that's an evolution that gets better over time». Robert Miller : «No». Jonathan Passerat : «C'est difficile. C'est difficile et c'est difficile pour deux raisons. Il y a les défis techniques, mais il y a des difficultés d'adoption par les utilisateurs aussi». Hubert Ridolphi : «Je pense que le challenge il est global par rapport à l'acceptation de l'intelligence artificielle. On a fait une mission pour un gros client du secteur public et certains de ses process allaient être aidés par l'intelligence artificielle. Il y avait dans l'analyse des risques, les deux premières lignes, c'était l'acceptation de l'intelligence artificielle par les différents intervenants, avec les questions qu'il fallait mitiger en avance, est ce que ça va me remplacer dans mon poste, par exemple. Et ça, c'est des questions naturelles que l'individu va se poser. Donc forcément, tout ça, il va falloir que ça soit plus claire que ça l'est aujourd'hui. je pense que oui, mais ça va mettre du temps».
Understandable and clear	Ahmed Banafa : «It's still evolving. It's not clear because both technologies are really technologies that not everybody understand. So AI I will be fine. People understand that. They see application of that one with Siri and, you know, with Aleksa and all the system. But the blockchain is the issue. Not many people understand. What is the blockchain. The only thing they know about the blockchainis, you know, bitcoin. That's so until we get them on the same level, same understanding that it's going to be clear and decide the

blockchain is foundational, it means it is within the system. You do not see the application until you use it».

Kapasi : « Tremendously. I mean, every year it's more than double in interest. So and how do we calculate those interests. With the project request we are getting, the proposals we are getting, as well as the project ideas we are getting from the client and the number of projects we are doing. So, you know, over the last three years it was more initially educating the client. So what is blockchain, the ideas and so on. Last year was more or less sort of project request coming from a lot of the use cases. How does this work? What are the type of blockchains,... And all those things. And this year is really how can we implement this along with different other technologies like AI analytics, IoT and so on, and how can we actually go to the market. » « I would say only 10 percent of the companies in the market see what is the value of it. Because normally, with blockchain, people think of cryptocurrency. There are so many myths about it, but nobody understands what is the real value it is bringing. »

Daniel Yasri : «Si on le propose à la population, non. Chacun a son domaine de prédilection. Certain connaissent bien l'AI, certain connaissent bien la blockchain, certains connaissent les 2. Généralement non, mais il y aura forcément un jour où les gens auront la double casquette et dans ce cas là ça va devenir facile oui».

Joan Van Loon : «Well, it depends who you talk to, I guess. I think not not for the general population, because if I talk to a lot of people in the industry there, they are not aware of. they all know something about it, but if they find it still difficult to define the right use case. And for me, understanding is about being able to define your use case because otherwise you have the technology. Technology is there. You do not need to understand all the technology in detail, but you need to know what to use it for and why to use it. And that seems to be still a big struggle. So I do not think they fully understand what the capabilities are and what the possibilities are and then translate it into a real use case».

Philippe Coucke : «Moi j'en vois l'utilité mais je peux vous dire que la plupart des gens dans le monde des soignants de un ne savent pas ce qu'est une IA, deux savent encore moins ce qu'est la blockchain. Il va falloir faire de l'éducation».

Julian Fifield : « No, not yet. We're still very early. »

Bill Inman : « No, I mean, we're still in the very early stages of both, but this decade, A.I. is expected to add 15 trillion dollars to the global GDP, the global domestic product. And we're going to evolve very fast. Blockchain is still trying to find its way as an enterprise product period. Right now it's basically a fintech novelty. Blockchain is not easy yet to be used now »

Robert Miller : «Yes it is».

Richmond : «I think most people in the world do not know what blockchain is, and of those that do, most of them will respond with something like 'do you mean bitcoin?' What's worse about this situation is that Bitcoin has attracted negative media coverage due to reported criminal usage and its inherent financial volatility. Currently large corporate can and do take advantage of blockchain technology, and it is going to take some time for this to trickle down to the SME market. I think the only way this can happen effectively is either the technology is built into a product or service and not specifically pointed to as a component and so the consumer ends up using it without even being aware, or we need specific business software consultation companies to advice and design company / organisation specific solutions. In short built into off the shelf product/service or a bespoke solution».

Natalia Monteiro : «I find this quite difficult because I haven't read too much about this topic »

Hubert Ridolphi : «Donc forcément, tout ça, il va falloir que ça soit plus claire que ça l'est aujourd'hui. »

Jonathan Passerat : «Non, non. Je pense qu'il y a beaucoup de bruit autour de ça parce qu'effectivement, ces deux techniques sont assez hype».

Technological literacy

Ahmed Banafa : «There should be some education, especially for the decision makers. You know, I give speeches to the companies for free just to tell them much the blockchain technology. And after I finished the talk, they really appreciate, we never thought it can do this, you know, so until they know about it, for them, it is cryptocurrency».

Daniel Yasri : « La population en général ne va pas savoir qu'ils utilisent cela donc il ne faudra pas les éduquer. Il faut augmenter l'éducation pour les gens qui s'y intéresse oui. Mais pas le reste. La population ciblée, c'est très important oui, pour comprendre et voir les use cases possibles. Il manque de développeur blockchain».

Joan Van Loon : «Yes sure! For blockchain and AI. A lot of people talk about AI, but if you really look what they're talking about, it's not AI, it's analytics, it's robotics. And that's not AI so even there is still a lot of literacy missing. But again, the literacy is missing. And then also the full overview of what is required to do it, because you need to know what the potentials are of AI and blockchain. And then you need to understand what is needed to reach that potential. And then you need to understand what you need to do to give the access to the data, to open the data, to provide data with great quality and so on and so forth».

Richmond : «AI is already using blockchain technology but the concept is difficult to grasp especially when the field is evolving at a pace faster than most product development cycles, which leads to products/solutions being redundant before they are even hit the market. What's needed is a different approach to this, instead of a plan to educate on how to use one specific technology, we should be educating on how to adapt to new technologies in a cycle of continuous learning and improvement. Right now you can go onto the SingularityNET market place and buy calls from an AI and leverage the blockchain, but at this stage many people do not realise the potential or know how to use the tools. One of the difficulties we face is that the change we are facing as a civilisation due to the implementation of strong AI systems is massive, unfortunately change is something humans seems to fight against... Ironic then that it is humanities ability to adapt that has enabled us to survive and thrive».

Julian Fifield : «Oh yeah, a lot. there's not an issue to do with the technology, the barrier to entry is people. They do not understand it, they do not, you know, they're not familiar with it and they're scared of the future. But for use cases around AI and blockchain, the technology is not there yet. So those barriers are people, not technological».

Hasen Kapasi : « First and foremost is awareness, education and awareness of this problem. because everybody, when we speak to any specific expert domain expert, they have their own expertise in that. And normally they do not understand the full picture. So, you know, over the last three years it was more initially, you know, educating the client. Right. So what is blockchain, the ideas and so on. Last year was more or less, you know, more sort of project request was coming from a lot of the use cases. You know, how does this work? You know, what are the type blockchain. And all those things are a little bit in detail. And this year is really, you know, how can we implement this along with different other technologies like AI analytics, IoT and so on, and how can we actually go to the market? »

Philippe Coucke : « Je pense que ça passe par l'éducation des futures générations des soignant. Ils n'entendent pas parler de ces technologies pendant tout leur curriculum. education, sensibilisation, explication».

Bill Inman : « Well, no, I do not think literacy matters. As long as it's easy to plug in information into the solution, nobody needs to know how it works. I feel like they need to understand how the decisions were made, but they do not need to know the inner workings, it's got to be like a browser. We do not ask how the Internet works when it serves on the Web page. We just read the Web page. So that's the ease of use that we're getting to. Nobody's going to care about how it does it, but they are going to care about whether it was biased or not.»

Robert Miller : « Yes definitely »

	Jonathan Passerat : « Il faut augmenter l'éducation et la couche de présentation aussi, comment on l'expose». Hubert Ridolphi : « Oui, c'est comme dans tout domaine nouveau, il faut, il faut déminer le terrain, peut être comment expliquer l'utilisation de la blockchain autrement que pour faire des cryptocurrencies. Ça commence un petit peu les articles là-dessus mais c'est difficilement vulgarisable, donc accessible».
Feeling and impression	Ahmed Banafa : « It's a perfect match, it's a matter of time for the blockchain and AI to work together. One of them is the muscle and one of them is the brain. That's basically why I look at it. » Joan Van Loon : «I have a bit of feeling that blockchain might slow down the advantages and the evolution of A.I. rather than speed up». Daniel Yasri : «On a hâte que ça arrive mais ça va prendre beaucoup de temps. J'ai hate que la blockchain arrive déjà pour les moyens de paiements etc donc qu'elle débarque pour l'AI, j'ai hâte. Et pour le domaine de la santé, combiné, c'est un rêve. C'est idyllique et utopique». Tim Richmond : «It's easy to feel both excited and scared about the use of AI, to what level of these feelings one experiences depends on ones understanding of the potential outcomes for the acceleration of technological growth. At every moment in human history where there was a technology that increased our ability to share information, we've undergone tremendous amounts of growth. What's vital at this point in time as AI models become more and more powerful is to ensure that this power is uniformly accessible to the world. what's more is as AI becomes more powerful it will need to gain an appreciation for human values, if AI was to be centralised, accessible and controlled solely by big tech, sovereign states or heavens forbid the military, then we could be in for a rough time given these do not place human values above their own specific goals. Ultimately AI technology belongs to humanity as a whole and Blockchain / decentralisation is how we get there.» Philippe Coucke : «Pour moi c'est incontournable, on doit embrasser cette technologie là, il n'y a pas d'autre choix. Aujourd'hui, on sait très bien que nos systèmes médicaux ne sont pas sécurisé du tout. Rien de plus facile que de hacker un hopital. Nous ne partageons pas nos données de façon sécurisé. Nous n'avons pas de traçabilité de ceux qui ont accès à des données. promenez vous dans un hopital, vous pouvez introduire un cheval de Troie ou un virus quand vous voulez et ou vous voulez, come vous voulez». Julian Fifield : «It's very, very, very early. The point is R&D at the moment. R&D, it's not real world use cases. It's in the lab. We have to remember the context, health care is very conservative. It's not a rapid adopter. In any event of any technology». Jonathan Passerat : « Je pense qu'on a les techniques ou du moins en fait, je pense qu'on a au moins une première version de tous les éléments techniques dont on a besoin. Maintenant, ça va prendre du temps de les polish pour bien les mettre ensemble et que ça soit quelque chose qui a du sens, en fait». Bill Inman : « I feel it's necessary as a solution alternative to Big tech Centralized AI. We've already seen that. Facebook got in trouble for leveraging AI and information in previous elections. And we need alternatives to centralized information, centralized solutions, especially around AI, because we need to be able to piece together the solutions on our own without somebody else, other platforms dictating that, it's just a very powerful solution. We need decentralized as an alternative ». Robert Miller : « I think it is immediately useful and in the more distant future, it offers the possibility of creating algorithms and technological services that are totally different and have a better relationship with users than today. » Hubert Ridolphi : « C'est encore tôt » Natalia Monteiro : « I do not think one requires the other. What I think is there are some areas where AI can be extremely powerful when combined with blockchain, because once you have got the traceability, the security, transparency of blockchain and access to more data, AI goes to another level because that's what AI needs, AI needs data. The better the

	more, the better is going to be a result. And I think blockchain could be a catalyst to it, but not necessarily. »
Attitude towards it	Ahmed Banafa : «Oh, absolutely. Yes, 100 percent». Daniel Yasri : « Aboslument, je plongerais carrément». Philippe Coucke : «Je crois que je sauterais dessus». Robert Miller : «Yes, It's my job. So, absolutely». Tim Richmond : «The acceleration of technological growth is on an exponential curve, the logical outcome of this is a point where change due to technological advance is happening so fast that it is not possible to predict or fathom the outcome. We call this the Technological Singularity. There are two schools of thought on the Singularity, some believe it to be a human ELE (Extinction level event), others believe it to be the gateway to utopia. Right now it is not possible for us to put down out technology and so whether we want it or not the Singularity is coming... the question is what form will it take. So therefore given that we have no real choice in this, we should do everything in our power to push this event toward a positive outcome, because the alternative is unthinkable». Julian Fifield : «I think it's a convergence, but not for a while». Bill Inman : «Already leverage blockchain for AI in a singularity». Hasen Kapasi : «I'm pretty excited about this». Jonathan Passerat : «Totalement, totalement » « Je pense qu'on a les techniques ou du moins en fait, je pense qu'on a au moins une première version de tous les éléments techniques dont on a besoin. Maintenant, ça va prendre du temps de les polish pour bien les mettre ensemble et que ça soit quelque chose qui a du sens, en fait». Natalia Monteiro : «I haven't really looked into this or I'm missing the opportunity». Joan van Loon : «Medium, both have potential and probability».
Probability to merge	Ahmed Banafa : « It's within five years that we're going to see some applications. In 5 years you are going to see application because people are really good at that. And then after that, in 10 years, it's going to be the norm. An added part of the blockchain will be the AI engine itself, like the smart contract AI engine. The blockchain will be there. » Joan Van Loon: « I think it's already difficult to work with one of them and it will be even more difficult to put both together. So again, if there is the right use case and in certain circumstances and for certain things, it will be done. Because it has the best potential. But in general, I think probability will be low and they will be put together. Because if I really to be honest, if I look today in the Belgian market and the cross industry, if you look at blockchain, there are people really struggle to find use cases for blockchain, while on the other hand, they do not struggle that much to find use cases for AI. So if you want to put both together, I have a bit of feeling that blockchain might slow down the advantages and the evolution of A.I. rather than speed up. » « It depends on what is what is the main priority if indeed it spins out, that it is more about data governance and auditability and traceability. Then yes, it will be needed and then they will need to be put together. If the priority is more about finding solutions fast and better fail fast than wait for the long term real solution, then blockchain won't have that much value for AI. So, it depends on what is highest on the agenda, the security governance story or indeed finding new solutions and then coming up with new answers. »

	Tim Richmond : « AI and Blockchain will continue to evolve and change form, but what seems clear is that the decentralisation of AI technology is central to the development of automation. Interconnecting many parts together and sharing data in a way that is both secure and transparent at the same time is critical in our future, regardless of what form these two technologies take. If you imagine a time in our future when all aspects of our supply chain are automated, each organisation involved in the chain all communicating and transacting between themselves you can gain an idea of the level of complexity that can arise as a result. Enabling a decentralised transactional model will vastly increase the speed, efficiency and security of these systems. » Hubert Ridolphi : « Je pense que oui, mais ça va mettre du temps » Philippe Coucke : « Oui, je pense » Julian Fifield : « I think it's a convergence, but not for a while. That's quite a way off. They are two separate activities at the moment. I think that may well converge in the future, but that's a long way off. » Bill Inman : « Within five years. I mean, you're going to have a convergence of A.I with blockchain, with robot, more with, you know, automated robotics. So it's not just it's not just AI and blockchain. It's all emerging tech converging. And accelerating. And it's those use cases that are going to be exponential. » Robert Miller : « Yes » Natalia Monteiro : « I do not think they really will emerge. They might they might not. What I think is, those are two powerful technologies. I see how powerful it can be when applied to the data. But to be honest, I've also seen some of our customers utilizing it without A.I. whatsoever because it's a small amount of data and can be done by an individual. » Jonathan Passerat : « Totalelement. Moi à l'heure actuelle, je refuse en fait d'utiliser des services qui ne respectent pas la privacy mes données. Et si demain on a ses garanties là, je serais ravi, par exemple. Parce qu'en fait, à l'heure actuelle, on est sûr de la médecine très, très générique en fait. Alors que si chaque patient avait une analyse très précise de son génome, qu'on savait quel potentiel de maladie tu vas avoir, qu'on pourrait anticiper en fait des traitements au lieu de le faire quand les symptômes apparaissent, parce qu'on sait que tu as tel ou tel risque ou que tu as tel ou tel antécédent familial ou autre. Ça serait génial et on aurait un gain énorme pour toute la société. À l'heure actuelle, ça veut dire donner ton génome à une autre entreprise qui contrôle, qui va le revendre à des boîtes de pharma sans ton consentement ? C'est déjà arrivé, hein ? Ce n'est pas de la science-fiction et surtout encore plus en fait, quand tu réfléchis. Pour moi, les données génétiques, c'est vraiment le truc ultime. Parce que parce que c'est des données qui sont hypers paradoxales. Quand tu donnes tes données génétiques, tu impliques ta famille. Si, tu décides de donner tes données, ils ont la moitié de l'ADN de ta mère et la moitié l'ADN de ton père est arrivé et ils n'ont rien demandé pour ça. Du coup, c'est terrible. Si on n'a pas vraiment de solutions de data privacy pour ces traitements-là, on a un vrai problème. On a un vrai problème de société, en fait. Et quand on arrive à le résoudre, à mon avis, on va aller plus loin. Ouais, j'ai hâte qu'on arrive à faire ça de manière normale, à l'échelle et que ce soit hyper intégré dans la société. » « Je la vois vraiment, pas pour le très court terme, mais je le vois si on arrive à mettre en place des choses assez complexes, comme je l'ai dit en fait, si on arrive à mettre en place de la gouvernance, ça, j'y crois. Mais pas forcément au niveau que de la donnée. En fait, je pense qu'on va arriver à mettre en place de la gouvernance de modèle d'IA aussi. De la monétisation, peut être. Mais ça, ça ne passera pas que par la blockchain. Pour moi, c'est la combinaison de la blockchain, oui, mais c'est peut-être 20% de blockchain et 80% de cryptographie »
Applications	Ahmed Banafa : « If you see that a certain hospital is registering a thousand cases a day, that will trigger some kind of alert to the World Health Organization. They can go and check everything and they're going to say everybody in this city should stay, should not leave. They're going tell everybody about that. Not waiting for the government to tell

	order because this alert will go to everybody in the network saying, listen, in certain place, this is what happened. So that is the beauty of using this for health care. I have an article, I'll send it to you two about blockchain and covid-19 how they work together. There are four areas that are actually helping with that one. One of them is a supply chain, the medical supply chain. The other one is the donation, because a lot of people donate for that part. And the third one is the crisis management. We talk about the crisis management; how can you deal with the travel alert for people based on what? It is because some government they shut down the airport. Some of them did not. There are some kind of systems that rely on information. We trust this information because it's in the blockchain and because it's a network that's shared with everybody. Then it's going to be a global alert, saying we're going to ban the travel to this country or this city and we're not going to accept it instead of waiting for political games and all these kind of things going on with that part. »
Power from big Companies	Ahmed Banafa : « You do not see big project from those companies. The only big project you can see is Libra from Facebook. That's which is the cryptocurrency. You have to understand that the big companies like Google and Facebook and Amazon and you name it all the big companies, they monetize on centralizing and collecting your data. When you have a decentralized, that's what the blockchain is, decentralized data, there's copies everywhere. There's no way for them to make money out of it because there's copies everywhere for it. And they have control on turning on and off using the smart contract. The concept of the smart contract is a very important concept here to say, yes, I give you permission, no, I do not give you permission to do that. And this is how are you going to stop them for this. And they're not happy with it. Trust me. They look at it and they're saying no, and that is why you do not see Google is excited about this or Facebook or LinkedIn or Twitter. Twitter yeah, they have a project about it where they can document the information. I know about Apple, they have the timestamp for the activities. They have it in the blockchain because that's going to help them track down any activities. But to use it for the data, you are depriving them from having the data under their control. » « This company Singularity, deals with this kind of problem, which is making it the fair for everybody. You do not have to just only rely on big companies. Now to deal with big companies about how to get the data we need regulation and this regulation would force them to give us the data. Otherwise, they're not going to give us this data. This is again, the regulation is another challenge you can face here, because you can have the best AI, you can have the best machine learning, but data is like a car without a gas. There's no, you know, no fuel there. » Julian Fifield : « No, there is definitely scope within blockchain solution to cut out some of the bits in a process that exists now. So you can capture that information and make that directly available to the to the consumer, for example. And you do not need some of the people in the middle to process. You certainly can do that. You can take out intermediary steps. You can concatenate and press the value chain. ». Hasen Kapasi : « Big pharma companies leverage it just because they have the money so they can have access to some of the company's data and some of the data recorders from the big research companies because they have the money. And if they find something good out in the market, they're capable enough to buy those companies so they do not have any competitors. But now in the future, you can actually track starting from the patent's right of it, and there are multiple models coming out in the market where you see a data, what is insights coming out? And you can actually sell each piece of the insights. So I think that is where there is no monopoly in the market, you know, because it is all open source. And then you can actually anonymously see what's out in the market. So this is how the markets are. But nevertheless, you know, the patent business and all the patent medicines, I think that will stay. ». Daniel Yasri : « Puis les GAFA n'ont pas trop de poids au niveau des santés patients. Ils ont beaucoup de mal à avoir les données patientes, c'est très compliqué. Je pense au contraire

	que ça leur faciliterait la tâche si on avait tout le monde sur une blockchain. Parce que ça leur permettrait de rémunérer les patients et les patients seront plus à même de transférer leur données et donc pour une fois, ça va plus dans leur sens. Je pense que ce serait vraiment une interconnexion et donc un gagnant-gagnant pour les patients et pour ce genre d'entreprises. Et au vu du cadre légal au moins dans nos pays, ils auront du mal à avoir accès à nos dossiers patients. Et ça justement, si on arrive à ce système, on arrivera à un moment où les patients voudront bien les donner. Et je pense que ce sera une bonne chose. Donner des données anonymiser bien évidemment, ça serait génial pour tout le monde».
Patient data monetization	Ahmed Banafa : « You can have, again, smart contract! You can program that by saying if you use my data, transfer that much money into my account. You can do that. Or transfer it or tell me that you want to inform me about it. And I can talk to you so I can have control on who access it when they access it instead of the concept you have in Europe, which is the GDPR, which is basically with the right to be forgotten, which is you can erase your information on the Internet, but you have to submit a request to Google so they can remove you. It's again, this is centralized. I do not want to do that. I want to have control on my own site where I can just say I do not want anybody to take my data. » Bill Inman : « Eventually but we're not there yet. Blockchain gives the power to individuals to share their data or not. It allows for somebody that has a cancer for example, to say, yes, I want my data to be published and yes, I'd like to be paid for it. So as Blockchain matures, then the individuals will be able to make that decision and they can either share their information or not based upon what their decision is. So it can help a lot for personalization because somebody can either donate their data or provide more of their data to third parties that companies can't have. » « The blockchain is a great use case for data to be leveraged by, so that people can actually monetize their information and also combine information because we need the fuel for artificial intelligence. Without that, it doesn't work very well. There's a whole bunch of different techniques that are being used in AI now to use less data, to create models and train models.» Jonathan Passerat : «Ca existe à l'heure actuelle. À l'heure actuelle, tu peux, tu peux te faire contacter pour participer à un clinical trial et être payé en fonction si tu donnes tes données. Et t'as pas besoin de blockchain pour ça. Donc, pour moi, pour moi, ça, c'est marginal en fait, ce que ça apporterait dans ce domaine là. » Hasen Kapasi : « Token, so rewarding the patients, the incentivising is really undermined at the moment in this auction topic, because at the moment, people do not understand. Why will they participate with you? It is one of the key question. And also going towards customer, why they care using your platform etc. And the answer to that is incentivising. I think that is the key topic which will be coming in the next couple of years. » « the first one is consent. First of all, if you're agreeing on sharing the data, you exactly know where your data is being used and who is, you know, using that. So you have the transparency. » « And the second thing is once you agree you have some kind of rewards mechanisms behind it, you get tokens or something just to share the data for research.» Robert Miller : « People just do not have the incentive to share health records today. And different health records speak different languages. Blockchain won't solve that necessarily. But like I was describing before, they may provide some context in which people can make the data useful. Like in federated learning networks or in a blockchain based machine learning marketplaces So it won't give people necessarily control or ownership over their information. I do not think, but it will give them new ways to use in AI and related systems. » Hubert Ridolphi : « C'est le patient qui va consentir à donner un certain subset de ses données, qui ne contiennent pas son identité ou qui son pseudonymisé ou complètement anonymisé en utilisant la blockchain pour justement vérifier que ces données sont partagées avec la bonne institution ou la bonne personne. Et éventuellement, une fois que la preuve que ces données sont partagées et utilisé, d'avoir un retour. La boîte Zentiva, a

	lancer une application ou vous pouvez justement stocker sur des serveurs sécurisés vos données de santé et les partager avec des acteurs pour la recherche, et donc en utilisant la blockchain, pour la recherche et vous recevez en retour des goodies. Ca peut être une réduction pour aller au théâtre, un genre de crypto monnaie que vous pouvez utiliser très facilement. La privacy c'est le pouvoir de partager avec qui on veut ses données et d'arrêter ce partage en étant sûr que ces données ne sont plus en possession du partenaire avec qui vous les aviez précédemment partager. Et la blockchain permet ça aussi, ou alors une gestion des consentements plus drastique, plus sécurisé. »
Emerging countries	Ahmed Banafa : « Well, it's going to help them with many things, number one is the example I gave you about the refugees. So having the information that's going to help them with this. So I can go and open a bank account, I can go and buy stuff, and I can do so many activities out of this. And the other thing is, that is making everything digitize. I mean, it depends on the infrastructure they have. So if I want to get my information, I can get it online instead of printing those papers and the paper is going to be lost or modified or counterfeited. So it will help make thing digitized. Many countries, you know, you can talk about countries like the United Arab Emirates, you can talk about other countries where they have something called the digital government. And the records are actually on the blockchain countries like Switzerland. And what they have done, they have the voting system which is actually on the blockchain so it is going to protect the vote, nobody can change it. Every time you need security and trust, think about blockchain. That's the mentality for any country. They are going to say, OK, you want security, you want trust go for the blockchain. It's not difficult. The government can do it because they have the money. » « Let's be honest about it. You're going to go with blockchain and people cannot find food to eat. Which one is more important. Which one is more urgent. Provide them with food and water, clothes and medicine. Or you want to go with the high technology. This is this kind of project that can be done by the United Nations. It's like the United Nations can go there, provide them with the food, providing this one, but keep records of everything on the blockchain. So to ensure there's no abuse of the funds, there is no corruption that the people and those governments do not abuse by taking the funds. So we'll give it to the people who deserve it. They have their name, they have their ID and they can give it to them right away. So the non-profit organizations will benefit big time from that. » Daniel Yasri : « Nous, on a toujours un problème de legacy systems. Donc nous on doit tout changer à chaque fois et les gens ils n'aiment pas changer. » « Alors que dans les pays émergents, vu que les choses sont à construire, c'est beaucoup plus facile pour eux d'adopter une technologie qui est de dernière sortie. Et la c'est une force pour les pays émergents, j'ai travailler avec le Maroc qui aime beaucoup la blockchain, l'estonie également même si ce n'est pas un pays emergent mais qui n'est pas un des pays les plus riches, et qui a su faire la transition du papier à la blockchain rapidement. Et le Nigeria, se met à fond là-dedans. Il y a plein d'exemple et ils le font, et ils le font bien. Parce que justement, ils n'ont pas tout à remplacer et il y a moins de resistance de la population. La population a rien de base donc c'est comme si c'était quelque chose de niveau qui marche. Tu ne dois pas remplacer un truc qu'ils connaissent. C'est donc une résistance dans les pays du premier monde, qui ne veulent pas bouger. Le fameux « tant que ça marche, on n'y touche pas » alors que c'est beaucoup mieux d'améliorer les choses. Mais par contre, le problème numéro 1, ça va toujours être pareil, ça va être les finances de ses pays là. Et également les cerveaux. Il peut y avoir des cerveaux locaux, mais ils veulent aller dans des pays où ils sont mieux payer. Donc niveau cout, est ce qu'ils pourront assumer le cout de la blockchain, du développement et humain vu qu'il faut des gens qui s'y connaissent. Mais

en termes d'adoption, ils sont bien plus enclins à adopter la blockchain que les pays comme nous. (...)ils ont tout à bâtir, ça va coûter. »

Philippe Coucke : « Je pense justement que l'implémentation de telles techniques soit probablement plus simple là-bas qu'ici. Pourquoi? Parce qu'il n'y a pas d'existence et que finalement, vous répondez à un problème de santé publique majeur et qu'il n'y a pas de structure, donc pas de batailles de clocher ni de bataille d'arrière-garde pour sauvegarder des avantages. Clairement je pense que dans les pays du tiers monde, ce type de solution sera plus rapidement que dans votre vieille Europe. » « Il faut savoir qu'on peut produire un smartphone pour un dollar. Dès le moment où vous êtes capables de faire ça, c'est quasiment accessible à tout le monde. Et ses pays là en voient clairement l'intérêt parce que justement ils n'ont aucune infrastructure et que c'est beaucoup plus simple de mettre quelque chose neuf en place que d'aller décrier ce qui existe et ça ira probablement beaucoup plus vite dans ces pays là. Un autre point important est que ces pays là n'ont pas affaire à des réglementations extrêmement sévères qui limitent tout cet échange de données et de technologie. Ce qui peut être un frein ici. »

Julian Fifiield : « Well, interesting question. I'd like to say, I think that actually that could be the case. If you do not have legacy infrastructures, you do not have legacy systems, you do not have legacy politics, you do not have legacy medicine. You do not have legacy services. An example with technology on that is EMPISA, which is a payment system that was used in Kenya. Which meant that people wouldn't have a bank or any money because they actually exchange value on their mobile phones. So electronic transactions on the phone peer-to-peer were years ahead of Europe and America. So brilliant example of technology helping developing countries, reinventing the old wheel, constructing the new wheel. But there was a use case you might look up just recently with Google. Google came up with an algorithm and a camera app. I'm trying to remember what it was for. I think it was Google DeepMind. I think it was to do with kidney disease. And so they tested it in the lab and it worked really well. And then they went to the field in the developing country to test it and it all went wrong. And it all went wrong because the conditions, the actuals on the ground, physical conditions were so bad. That was not a technological problem, it was an implementation problem. We couldn't actually use the technology. It physically couldn't be used in a meaningful way because the conditions are so bad. So whilst I'm optimistic about developing nations leapfrogging and not making the same mistakes that we've all done, there are other issues to handle. Chaotic politics, lots of other conditions which do not relate to technological use cases which get in the way. So I'm afraid it won't always be the case, unfortunately, that developing nations can leapfrog. If you look at broadband adoption, Tesla have launched a new service called Starlink. All these satellites, which means if you're in the middle of nowhere, there's no telecoms and there's no infrastructures and there's no broadband in the ground or anything you can get a faster signal than I can here. Brilliant. I'm sure they'll be able to adopt that. Why spending a lot of money on old-fashioned wires and fibre optics when you can get it straight from the sky. So I think there will be a lot of adoption in that place, but not necessarily adoptions in health care, because I think it's a bit messier (...) I think in some use cases it will be easier »

« I think in some use cases it will be easier. For example, I'm working on a discussion at the moment with South Africa where we're looking at trying to prove the provenance of their citrus fruits. I think they will be better and faster adopters in that case than in the developed world where there's too many barriers, politics and all sorts of problems and legacy thinking. In this, they'd probably be a bit more entrepreneurial. So I think there will be some use cases where they are positive adopters, faster than any other developed nations. »

Robert Miller : « I think certainly there are less data privacy protections in developing countries. So, that might be helpful to some people to go to places where they do not have to play by the same rules. I mean, personally, I can tell you that when I was at MedicalChain, we had somebody that told us that they could get us access to over 10

	million health records in China if we were willing to come and like sign a business deal with them. So I have first-hand experience with this and I do not know, we never face that down and it sounded like kind of sketchy. And the problem I think is that in lower income countries, you won't have the same kind of technical talent that you will in other places like the blockchain world and the machine learning world is remarkably concentrated on three or four places for machine learning It's basically San Francisco, a little bit of London and then a little bit of China as well. I do not know where in China. For the blockchain world it is San Francisco, New York, a little bit of London and Singapore, I think, basically. And you would be hard pressed to find the type of people that you would need lower income countries. » Tim Richmond : « This technology has the best impact on developing countries (...) Blockchain is an amazing thing for these people because it just means that people who have no ability to access resources can now access it readily. It means that they can monetize their work on the same level as like developed countries. So the technology is liberating for any developing nation that has access to the Internet. And with Ethiopia, they recently shut down the overall Internet. » « There's a lot of really intelligent people. So if I was an AI developer or I was a developer, I would be able to monetize my algorithm and receive money. It's impossible for some of these countries to transact in any kind of currency. So it's possible to monetize that and start to create the businesses and the foundation of every country's growth is each individual person being able to increase their own standing. » Hubert Ridolphi : « Dans les pays développés, les pays émergents sont moins réticents à adopter de nouvelles technologies en général. » Joan Van Loon : « In both of them. Is not related to countries, but to available infra, availability and access to data, quality of data, etc... »
Blockchain work	Daniel Yasri : « Avec le 256 Les risques de collusion sont extrêmement, extrêmement faibles et d'ailleurs on est passé au sha 512 maintenant parce que pour être encore plus sûrs. Mais les risques de collusion dans le sha 256, en fait, ça serait le risque qu'un autre truc soit égal à ça. Par exemple, c'est assez impressionnant, genre si je tire un point, tu vois à quel point tout change. Ça n'a rien à voir. Et ça, c'est la base de la blockchain aussi. C'est que grâce à ça, c'est comme ça qu'on a ce qu'on appelle la sécurité asymétrique. Ça veut dire quoi? Ça veut dire que si je te donne ça, un jour, je te renvoie, je te dis tiens Meriyem, si je te le donne comme ça, tu ne peux pas lire. Mais en fait, ce n'est pas ça le but de la blockchain Et c'est pas ça le but du Hash. C'est ça qui est très fort. Le but, c'est que si je te donne ça, tu peux vérifier que quand je t'ai envoyé ça, c'est bien égal en effet à ça. ». « Quel intérêt ça a du coup? Ce sont des algorithmes qui rétablissent la confiance. C'est la confiance qu'on veut dans la blockchain. C'est ça. Moi, je veux savoir que si mon médecin, il a dit que j'avais du diabète, si je reçois ce truc là-bas, c'est bien égal au diabète, sur ma blockchain, je veux que ce soit ça. Ça me permet du coup de signer. Tu peux signer via un hash. Tu ne peux pas être le seul à avoir un hash et dire Voilà, moi, j'ai ce hash-là plutôt qu'un mot de passe. Ça sert aussi à vérifier l'intégrité. » « Il a un entête, le hash du bloc précédent, Le nombre de transactions le PoW, c'est le nonce, qu'on appelle, ce qu'il a recherché pour créer ce bloc et son propre hash. Du coup, dans le bloc 7, par exemple, si t'es au bloc 6, dans le bloc 6 tu as le hash du 5, le PoW du 6, et le hash du bloc 6. Dans le 7 tu vas avoir l'entête du 7, le Hash du Bloc 6, le PoW 7 et le hash du bloc 7. Et ça, du coup, ça fait qu'en effet, c'est immuable parce que si tu changes, justement, c'est ce qui fait que la blockchain est immuable, si tu changes, ne serait-ce que je veux changer, par exemple je veux changer le bloc 6, sont hash va changer parce que en fait le hash du block 6, c'est la somme des transactions en hash. Si tu modifie une transaction, je vais mettre 1000 euros au lieu de 100, tu rajoutes un truc, le hash du bloc 6 va changer et le bloc 7, il va dire ben non, en fait ce bloc, ce n'est pas celui qui vient avant moi, parce que moi, j'ai le hash du bloc 6 avant et ce n'est pas le bon et du coup, tu vas juste te faire rejeter. Tu dois savoir que dans une blockchain, ça ne fonctionne par La majorité, entre

guillemets, c'est pour ça qu'on décentralise à travers des nœuds. Donc, il y a si un nœud s'amuse à changer le bloc 6, tout le monde va lui dire ben non, désolé, ce n'est pas ta version de la blockchain qui est vrai. » « Tu as bien compris hein c'est irréversible, c'est à dire qu'il ne sait pas craquable. Il n'y a aucun ordinateur au monde qui peut craquer, ça, ça n'existe pas. Si je tape des trucs qui n'existent pas, genre ça, personne ne va trouver que c'est égal à mon message, c'est pas possible actuellement sur Terre. »

« Il faut comprendre que transactions, ça va juste faire un input sur la blockchain. D'accord? Il suffit de signer un message ou une transaction, un input avec ta clé privée. Ta clé privée, c'est ce qui permet que toi, tu rajoute des trucs à la blockchain (...) ta clé privée, c'est à dire que c'est quand c'est toi qui veut faire les choses à côté, tu as une clé publique clé publique. Une clé publique, c'est quand tu donnes ton adresse aux gens, par exemple pour faire le parallèle avec le bitcoin, mais c'est pareil pour le dossier médical. La clé publique, si tu me la donnes, pour que tu m'envoie de l'argent. La clé publique, tu ne peux rien faire. Si je te donne une clé publique avec laquelle je regarde, mais ce qui n'est absolument pas obligatoire. Et donc avec la clé publique, tu peux juste m'envoyer l'argent. Avec la clé privée, tu as accès à mes fonds, donc accès à mes données patients par exemple et avec la clé publique, tu peux voir mes données patientes, mais tu ne peux pas les modifier. » « Ce qui peut être fait aussi, c'est ce qu'on appelle avoir des oracles. Ça, c'est super important. C'est quelque chose que je prêche depuis des années et c'est le plus important. Les oracles sont des gens qui vont certifier les choses. »

« Il y a 3 types d'interopérabilités, il y a la sémantique, structurelle et fonctionnelle. C'est très important, surtout en médecine. Tu devrais aller regarder. La sémantique ça permet l'interprétation des données échangées, sur la syntaxe mais aussi sur ce qu'elles veulent dire. Par exemple, la structure se serait patient A, telle maladie : etc. sémantique c'est à dire qu'il comprendrait qu'il y a plusieurs champs. Ça c'est la syntaxe, la structure mais que tel champs, à quoi il est égal et donc que tel champs, maladie ça veut dire maladie. Interopérabilité structurelle c'est quand un format de la donnée clinique est changé, est garantie que les données reçues sont préservées et se rapporte au champ de donnée. Il voit qu'il y a différente tram dans la structure, par exemple qua Patient A Meriyem, ce n'est pas égal à diabète, etc. Et fondamental c'est ce qui permet d'échanger des données de santé, sans hésiter que ce qu'elle reçoit, elle est capable d'interpréter les données. Ça c'est le plus bas niveau d'interopérabilité. Le but c'est d'arriver à des niveaux toujours plus élevés dans l'interopérabilité. Donc du coup, partir de la fondamental pour arriver à la sémantique. »

« C'est signé par la clé privée qui va du coup va ajouter un hash à la transaction et qui va montrer en effet que ça appartient bien à telle personne. Elle est signée par l'expéditeur, après elle va être entre guillemet signé par le nœud qui va valider la transaction. »

« Le fait qu'il peut mettre ses propres dossiers, savoir qui a accès. Par exemple, je suis psychiatre, ton patient, il est mal vu, les gens disent qu'il est fou, etc. C'est dommage, c'est une maladie. Du coup si tu veux aller chez un médecin avec tout ce qu'on vient de dire, tu peux juste choisir en cochant, je souhaite donner accès qu'à cette partie à cet oracle et comme ça il a accès à tout, sauf aux données psychiatriques. Ce qui est déjà le cas dans notre système. Ça permet vraiment de mettre le patient au centre. Au centre de ses données. Tu vas sur ton téléphone et tu sais enfin ce que tu as. Tu t'impliques. Egalement, si on avait du big data, ça permettrait que le patient puisse monétiser ses données anonymement via la blockchain. Ce serait facile via la tokenization s'il reçoit une notification avec : nous cherchons des patients diabétiques, tu dis ah ben bien sur ça ne me dérange pas d'échanger mes données et puis par exemple tu reçois en échanges un cryptomonnaie par exemple. Alors que maintenant, les dossiers patients sont vendus sans leur consentement. Il faut savoir aussi que les données médicales coutent plus cher en termes de marché noir que les données bancaires. Pourquoi? Aux Etats-Unis, ils ont un système d'assurance ou si tu as certaines conditions médicales comme le diabète par exemple, tu as droit à certaine chose. Et donc c'est ce qui est le plus pirater. Plus d'une assurance sur 3 est frauduleuse aux USA. Ça leur fait près de 68 milliards, c'est une grosse

perte. Ça mettrait également le patient au centre. On doit pas lui poser 36 000 000 questions, vous êtes sûr, ce n'est pas pour avoir de l'argent? Ben non regardez, 3 oracles ont signé en disant que j'étais diabétique. » « Il y a plusieurs réponses. Ça dépend du type de blockchain, si c'est public personne ne connaît ton adresse, personne ne connaît la transaction, normalement c'est qu'entre nous deux. Tu connais mon adresse, je connais ton adresse, que nous deux pouvons vérifier. Soit c'est une blockchain privée. Dans ce cas-là, si tu n'es pas oracle, tu ne peux pas voir les données publiques des gens. Fin si c'est une blockchain de consortium. Une blockchain privée c'est encore plus restrictif, si tu ne fais pas partie, tu ne peux pas avoir accès à la blockchain. C'est comme ça qu'on respecte l'anonymat, c'est en mettant des master key moi je dirais. C'est-à-dire que tu as une clé privée pour chaque utilisateur, il y a des gens qui ont plus de pouvoir sur leur clé et bien sûr c'est clés devraient être audité. Et donc on aurait accès au dossier patients, parce qu'on est médecin, parce qu'on a fait des études et qu'on a fait un serment etc. Et là c'est pareil, on devra distribuer les clés aux bonnes personnes les master key, les clé oracle. C'est plus sécurisé que maintenant parce que il suffit d'avoir le mot de passe du patient pour avoir accès à tous les dossiers des patients. Alors que si c'était une clé privée, ce serait autre chose. Il faudrait une authentification à deux facteurs. Et ça, ça permettrait encore plus de garantir le problème du patient car même de nos jours, un médecin peut avoir accès au dossier patient de n'importe qui même s'il ne l'a pas pris en charge, même si ce n'est pas permis. »

Julian Fifeild : « No need of a person to validate it. It is completely thanks to the rules that have been established before. » « Correct. Now someone has got to write the code. That's why I come back to my point earlier. The most important thing is the validation of an authenticity process of a product or service or a person or whatever it is. So a drug or a product, you've got to have this validation and then that gets encoded. And it can't be corrupted. If you're manufacturing a product, for example, in factory A, which components B and timestamped C and whatever it is, whatever the layers of authentication are important, you then start to try to do something else. The machine will throw it out. It will go. You're not allowed to manufacture that product because it's not in the right factory. It could be as simple as that. And therefore, the governance arrangements and people often talk about blockchain as a governance agency, but it's enforced by a machine, not by people or a central authority. »

Jonathan Passerat : « Une blockchain, il y a cette notion de chaîne de blocs, de blocs de données qu'on ajoute petit à petit et la manière dont on représente les personnes, les accounts, les utilisateurs sur la blockchain, c'est par une clé privée. En fait, quand on compte sur ton wallet, c'est la clé privée. Et ce que tu peux faire avec une clé, avec une technologie de clé privée comme ça, c'est d'une part signer une transaction ou signer n'importe quel message. Et une signature cryptographique, c'est quoi? C'est juste, c'est juste montrer via une technique de cryptographie que tu possède une certaine clé privée. Et du coup, ça, ça veut dire quoi, ça veut dire que si tu possèdes cette clé privée, tu contrôles l'account qu'il y a derrière cette clé privée. Du coup, si toi tu signes une transaction, si toi tu signes un mail ou quelque chose, je peux avoir confiance que ça vient de toi puisque a priori, ta clé privée, y'a que toi qui la connaît. Sinon, t'as un problème avec ta clé privée. »

« Les données anonymes, c'est ce qui a été pas mal étudié, en fait, ça ne marche pas. En gros, les données anonymes, c'est juste une manière de donner un peu de confiance. Mais on a énormément d'études qui ont été faites, en gros, même des données anonymisées, on arrive à les identifier en les retrouvant avec d'autre sources. Et en fait, à l'heure actuelle, si on commence à accentuer ce phénomène, à partager toujours plus de données anonymisées qu'on va pouvoir recouper avec les réseaux sociaux, les choses comme ça, on se tire une balle dans le pied parce que ce qu'on va faire, c'est créer encore plus de problèmes et de fuites de données. En fait, je pense qu'il est vraiment temps de dire stop aux données anonymisées. On sait faire mieux maintenant. Il y a des idées techniques, qui sont bien supérieures et qui donnent des garanties bien meilleures à l'anonymisation de

	données. Et il est temps de dire stop au partage de données en clair. Et je pense que si on prend cette décision là, ce n'est pas évident, mais on va avancer encore plus dans le domaine de la santé. »
Other	Daniel Yasri : « La blockchain, ça a été une mode dans les années 2016, 2017, 2018 ou on faisait que parler de ça tout le temps. On voulait mettre la blockchain à toutes les sauces. Alors que, moi qui suis dans la blockchain depuis 2011, et qui a essayer plein de trucs et conseillé des entreprises, il y en a qui voulait utiliser de la blockchain pour tous et partout. La blockchain, ça sert à: transparence, sécurité et intégrité des données. Ce sont les 3 choses que ça permet de résoudre, ça ne va pas faire plus que ça » Joan Van Loon : « But within health care, there are also specific rules which are even stronger than the GDPR rules for health care because about personal data, personal sensitive data. But these data cannot be erased. » Julian Fifield : « Using artificial intelligence to scan through images, radiological images, X-rays. And they do it better than the human. And that's because they've got a trusted data set. Basically, they train it on images, x ray images with a human that train it, and then it learns far faster and it's more accurate than many human interactions. So if you're a radiologist, this is good news because it means you can combine your experience and insight with a machine which will help you not miss things or you've had enough day and you it's very easy to mess things up so AI can be super helpful in that in that context. (...). Although that's getting better because this is a big development in what's called adversarial networks so that the algorithm is improving a lot such that you can do a lot more with less data. » « The problem is, again, a lot of these issues aren't technical. They're political. The problem is that everybody wants to suck data in, they want to know where you were born, what age you are or what, and that's because we do not have any identity. You do not have a verification identity. One point of identity, nobody's got a proper identity. You have to have all these different checks and balances in the system to basically prove your identity. With blockchain, you could eliminate all of that. You can just have one proof of verification is the blockcahin that will deliver to you, and you wouldn't have access to any other private information. But politics, call it politics, is what gets in the way of that, that's not technical stuff. » Bill Inman : « For joint decision making, blockchain is the information, AIs are the algorithms that provide insights. Combining AIs often leads to different types or even maybe even breakthrough insights. So that's how they can jointly create decisions. Blockchain provides the information though. » « Well, right now there's a blend of cloud based solutions on premise data and that may be stored at the AI provider itself. So enterprises are not extremely enthusiastic just yet about storing their data at the AI database because for security purposes. They do not want it to be stolen or even leaked. So there's that connectivity between the A.I. itself and the enterprise. So that's the first level of connectivity. That's what I most people to say "well, I'm on Azure. I'm just going to use whatever AI tools they have or I'm on Salesforce for sales and I use their AI. or I am on NYS to use their tools because they're comfortable storing their data in the cloud". But a lot of companies have their data stored on even old and even super old systems, that it's not easy for them to unlock the information for AI. So first you have the interoperability of just taking the legacy internal enterprise system and then making that available to the AI to use. And then on top of that, there are so many narrow AI that do very specific things, some for computer vision, some for natural language processing to be able to combine those AI right now. It takes a lot of custom work inside of the enterprise to bring all those pieces of a car together to make a car. There simply not enough AI talent to do that around the world. There's a lack of a talent level and data scientists. So being able to connect the

data interoperably, being able to integrate all of these different AI that are already pre-built is tough because there's no enough talent. And then if they wanted to create their own proprietary AI enterprise, they're often reinventing the wheel and just blowing money because all these things have been created. They just didn't know what was out there. So there's several different layers. But interoperability challenges are obstacle. »

Hasen Kapasi : « I mean, every year it's more than double in interest. So and how do we calculate those interest as the project request we are getting as well as the proposals we are getting, as well as the project ideas we are getting from the client and the number of projects we are doing it. So, you know, over the last three years it was more initially, you know, educating the client. Right. So what is blockchain, the ideas and so on. Last year was more or less, you know, more sort of project request was coming from a lot of the use cases. You know, how does this work? You know, what are the type blockchain. And all those things are a little bit in detail. And this year is really, you know, how can we implement this along with different other technologies like AI analytics, IoT and so on, and how can we actually go to the market » » why companies are doing it. As I mentioned, you know, they need to start now so they can they can reap the benefits in 2023 or 2025, you know, because that's where they will be able to reap the benefits out of it » » at the moment I'm working with the pharma company, I would say five pharma companies, one of the top five from our company, and they are implementing a blockchain based platform where we're connecting IoT, analytics AI, machine learning and blockchain » « I was actually very surprised to see those kind of projects coming from the pharma companies. »

« Exemple : So if you really want to track any product information, let's say, you know, like aspirin, you're using it. So at the moment, if you go and buy aspirin, there is a market on it. So, you know, there are only a couple of systems which can read market across the supply chain, how is it ratings, so if you want to say, OK, I want to know how my aspirin is coming tomorrow to me, who is producing it, that has to be a common language or common data point across that supply chain. This is a supply chain example. But if it's like any to research right, that has to be some common language. So, for example, for that product, considering aspirin, it's a physical product. It doesn't get any data and it has been in the SAP of a manufacturer. But that is not a digital identity of that specific package, which you are buying it. So for that, you need a lot in IoT, what we mean is dynamic QR code or anything which connects that digital product or physical product into a digital product. That's where, you know, you start your digital life. And then so you need to think of like, OK, first of all, you are transferring from physical to digital and then IoT based tracking. So you are tracking it now with IoT. You are automating some of the processes using blockchain and bringing the trust. Now you can believe that you have a data which you can trust. Right. And you have a full single source of data which you can use for machine learning. Once you say, OK, I used a machine learning with this data, now I can make a smart recommendation. That's where the AI comes. So this is like a complete lifecycle of it and AI and advanced analytics is ready, you know, like brothers. So what is what is the difference is, AI is really for the recommendations. You see, OK, you know, you see a nice dashboard. Look at what's happening across the time horizons, across the products. »

Robert Miller : « In normal machine learning, you are taking a bunch of data from a bunch of different parties and you're centralizing it into one database and federated learning instead keeps data at the edge and it brings algorithms to the data. So what that means is you can have a network of different parties that are collaboratively training an algorithm. They train the algorithm on their local devices. Like your smartphone works for Siri and predictions of words that you're typing. So you'll have data locally on your phone, your training algorithm on it, and only the algorithm will get shared with other parties and Google or Apple or some central party will take all the algorithms from all of our smartphones and put them together and they're like a meta algorithm or a global algorithm. In their words that takes all the incremental improvements from my

smartphone, someone else's, and mashes them into one to make much better improvements than us individually. And this is a way in which you can train an algorithm in multiple parties, but without any individual party revealing their underlying data. Where those things with blockchain, and I wrote about this in my article, is providing a way to orchestrate this process that no single party controls. So today, Siri actually works in this process that I'm talking about with Federated Learning where like you train the Siri algorithm on your phone, but all of that is controlled by Apple. And you have to trust that Apple is not doing anything nefarious. But you could stand up and consensyshealth is creating better networks that no single party controls. Instead, the network collectively decides what kind of algorithm runs on the Federated Learning Network.»

Natalia Monteiro Monteiro : « The way we do it within our company is that the smart contract can be revoked. So the data that a patient shares, he can share either for a definite period of time. »

Jonathan Passerat : « Je pense que c'est un bon outil, mais vraiment, j'ai du mal à le voir, en tout cas dans la santé, je ne pense pas que c'est un outil qui puisse se suffire à lui même. Ça peut aider en combinaison avec d'autres outils comme la cryptographie avancée. Mais la blockchain, seule pour la santé, j'ai du mal. »

Ahmed Banafa : « Smart contract is a very important concept in blockchain. There's no way for you to have a good blockchain system without having a smart contract. »

