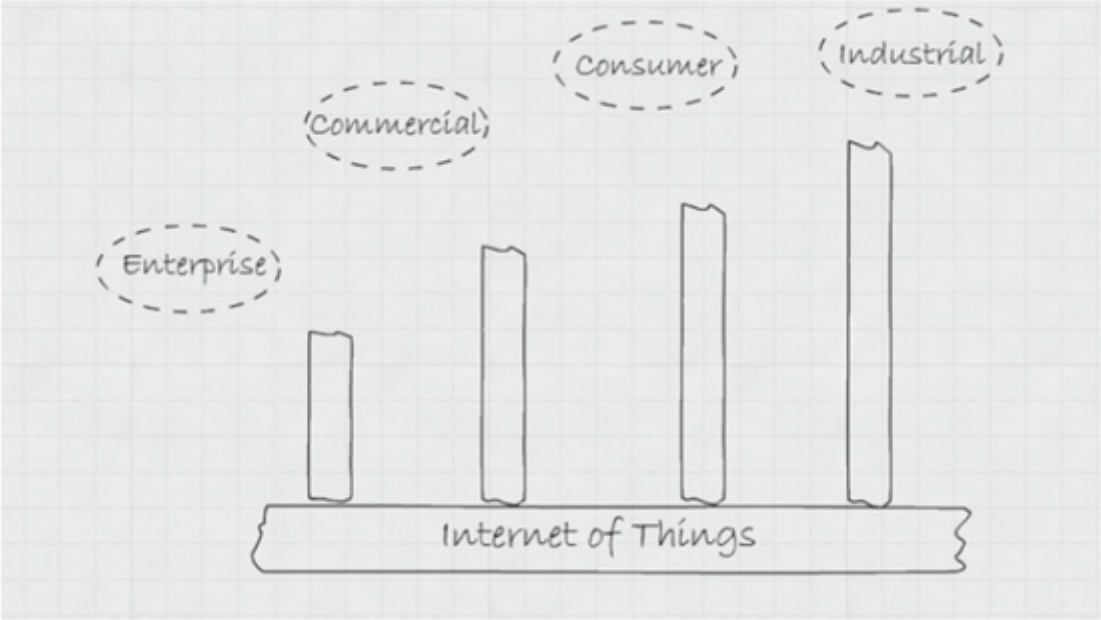
Appendix A

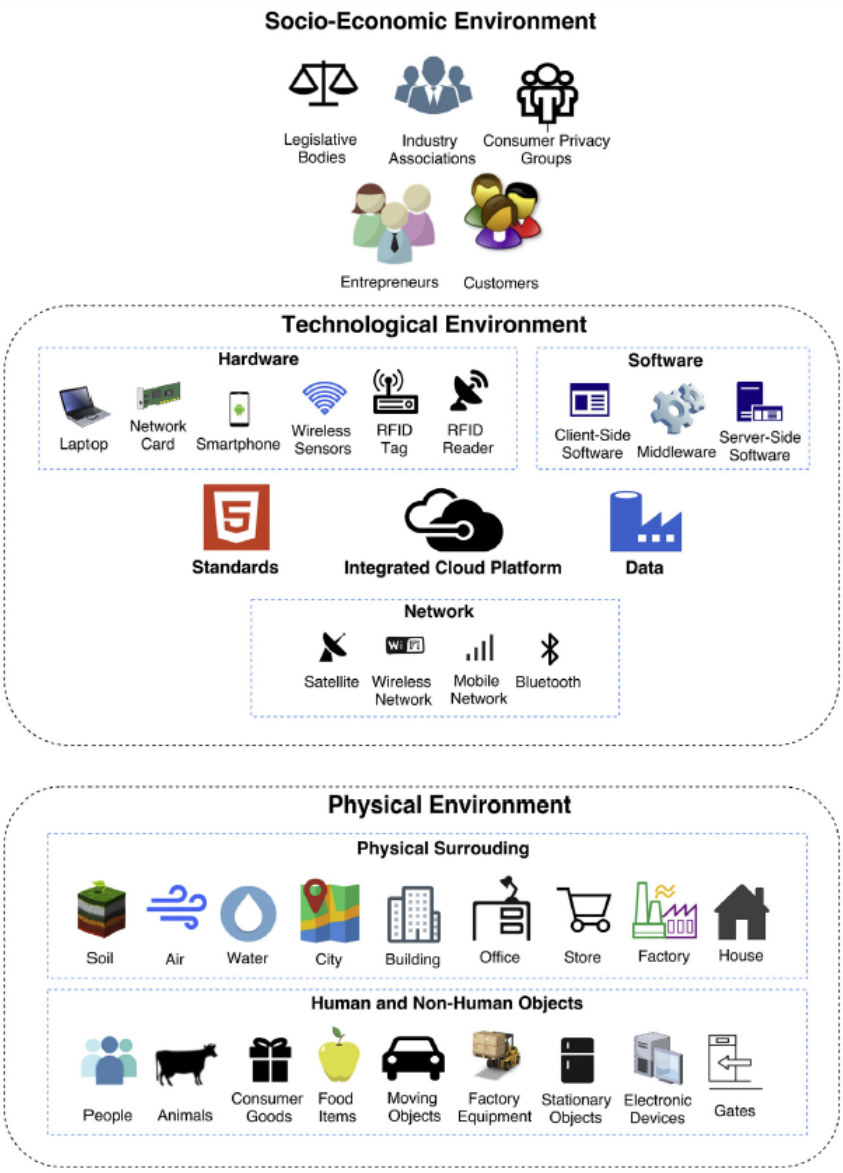
Illustrations and graphics

A.1 The vertical aspects of the IoT



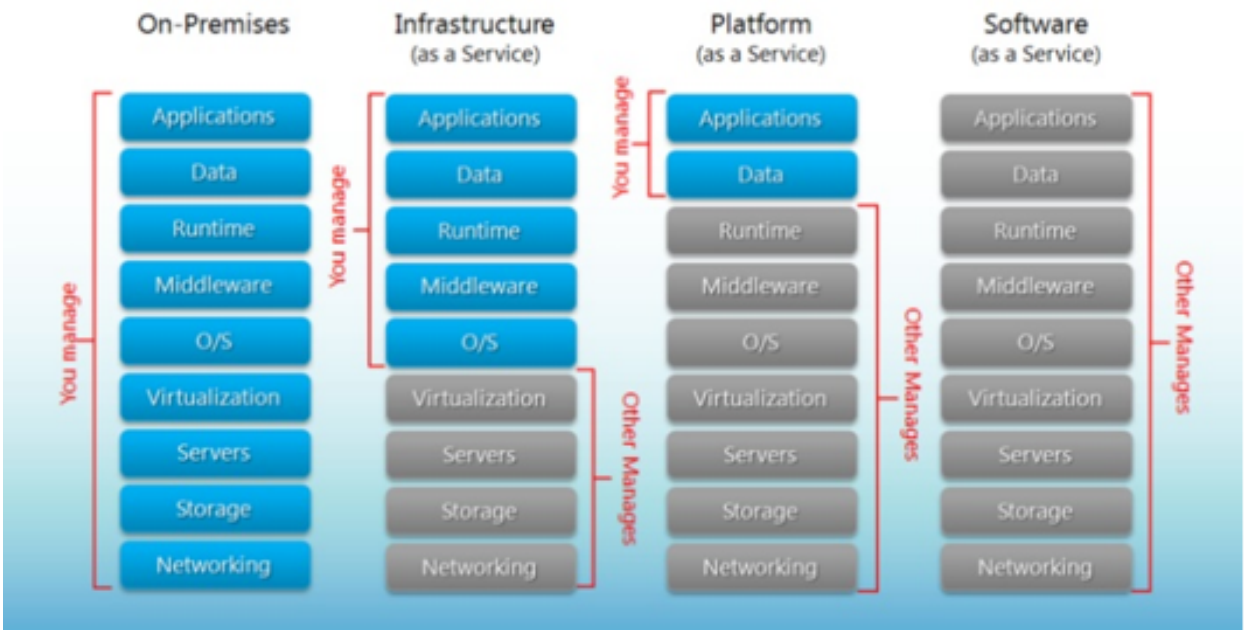
Source: Gilchrist, 2016

A.2 Environments and technological nodes of the IIoT



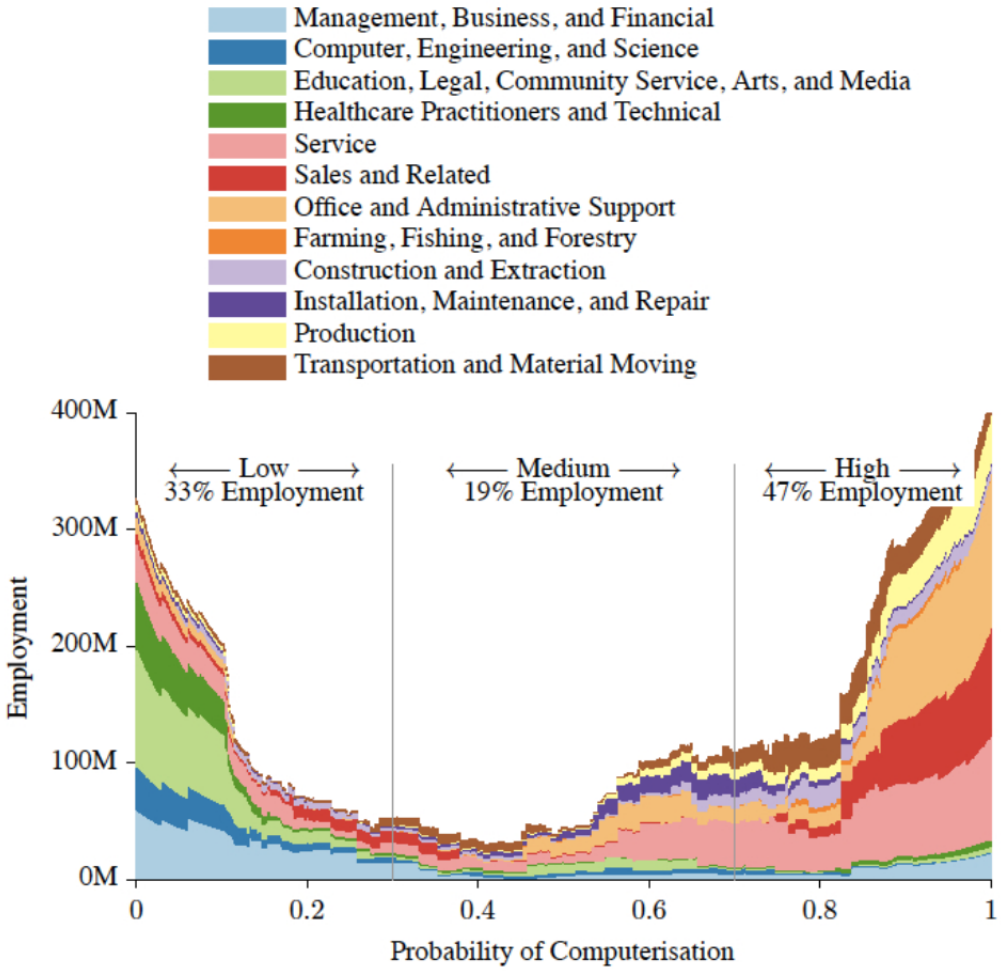
Source: Krotov, 2017

A.3 Responsibilities of integrated platform solutions in the case of Microsoft Azure



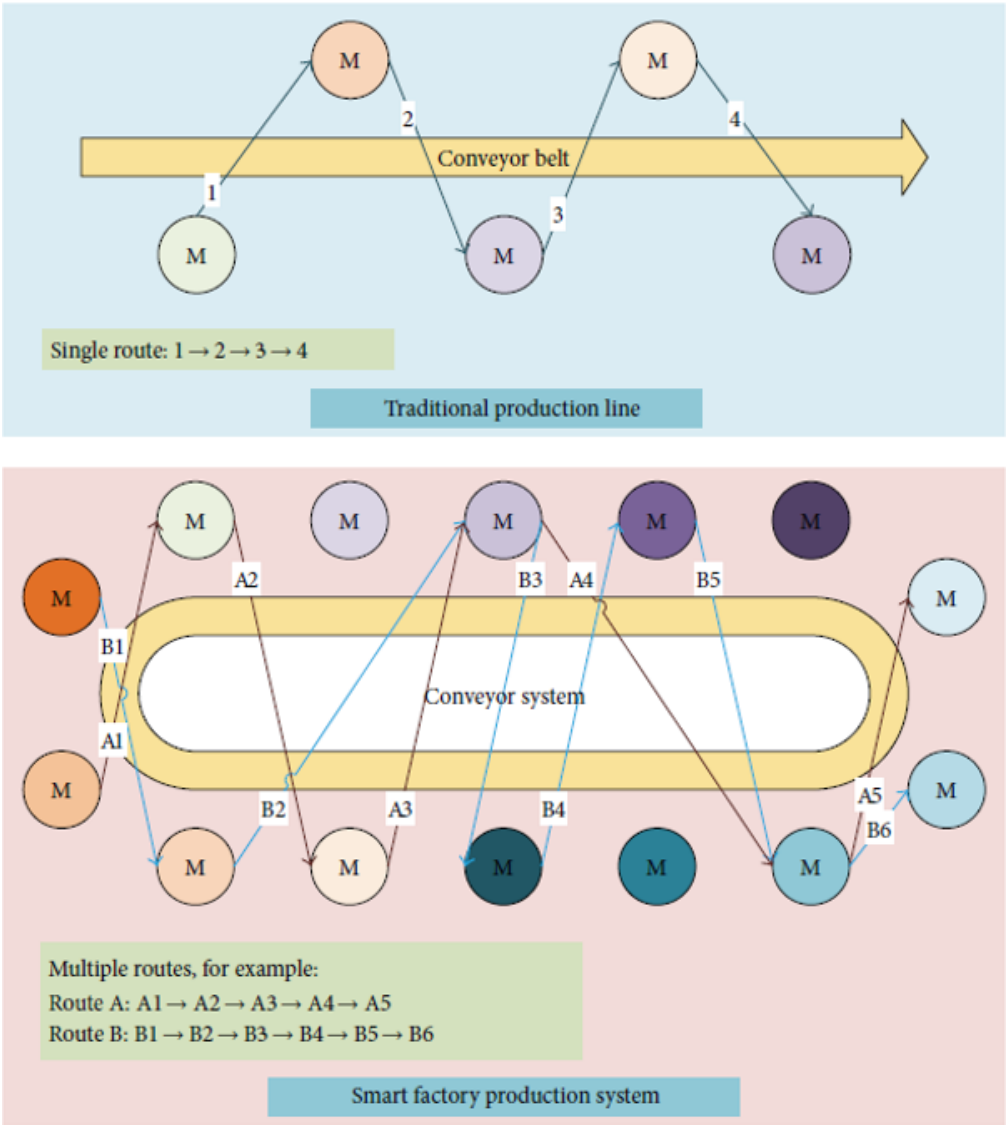
Source: Greiner, 2014

A.4 The impact of the fourth industrial revolution on the job market



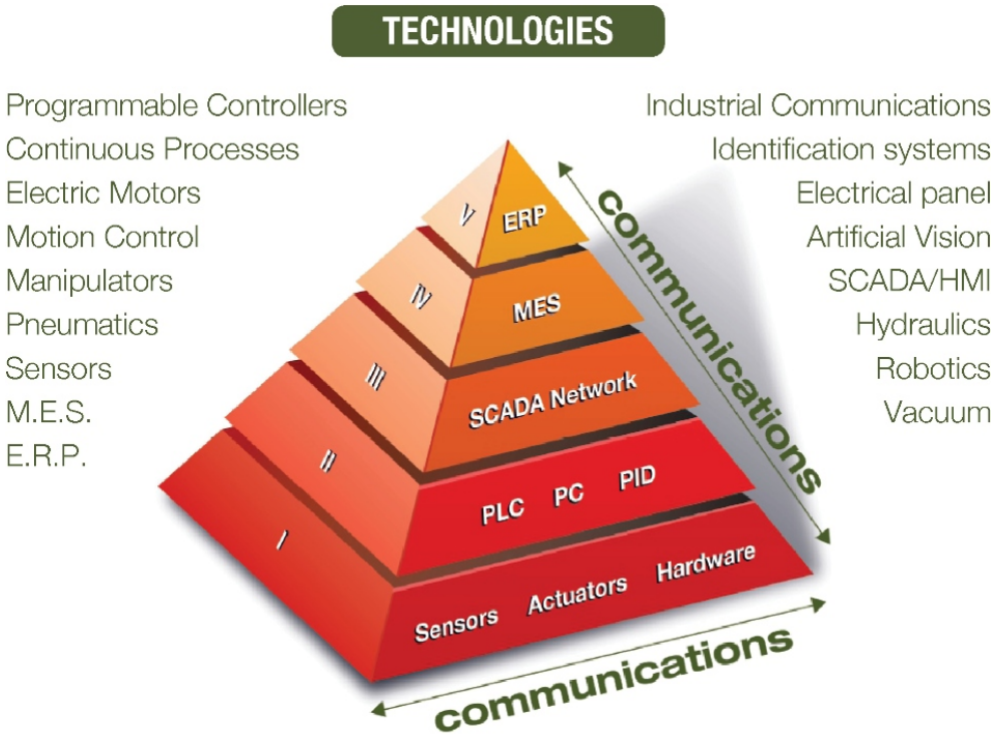
Source: Frey and Osborne, 2013

A.5 Illustration of the traditional production line and smart factory production system



Source: Wang, Wan, Li, and Zhang, 2016

A.6 The automation pyramid: an example from the SMC Corporation



Source: SMC, n.d.

A.7 Technical flow chart of data communication between client and server using RFID

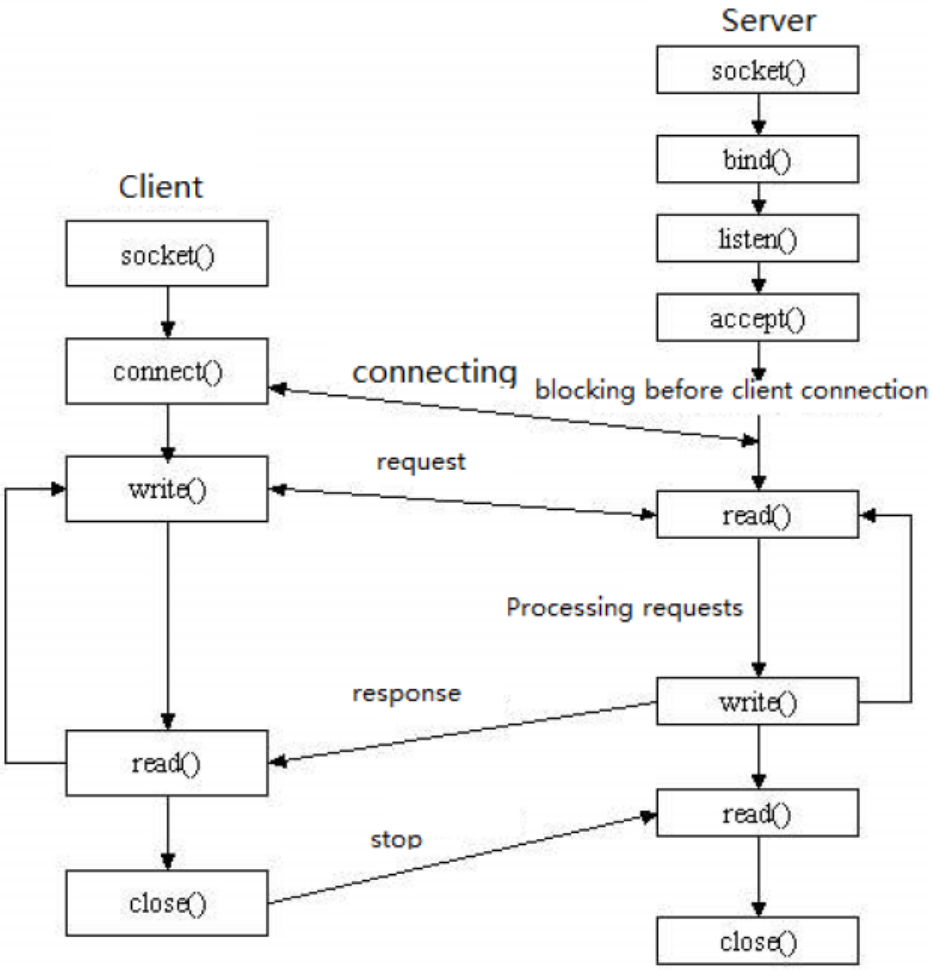


Fig. 2. Flow chart of data acquisition

Source: Zhao, Yu, Wang, Sui, and Zhang, 2015

Appendix B

Questionnaires

B.1 List and summary of questionnaires

1. **Questionnaire 1:** Supply chain strategy, sales and purchases. This questionnaire targets high-level supply chain managers or COOs, for questions related to the SC strategy, sales and purchases flows.
2. **Questionnaire 2:** Production and maintenance. This questionnaire targets production/manufacturing and maintenance managers.
3. **Questionnaire 3:** Inventory, warehousing and logistics. This questionnaire targets inventory, warehouse and logistics managers.
4. **Questionnaire 4:** Transportation and reverse logistics. This questionnaire targets transportation and logistics managers.
5. **Questionnaire 5:** IIoT and I4.0 professionals. This questionnaire targets IIoT or I4.0 professionals, willing to answer general questions about the concepts and their link with the SCM discipline.
6. **Questionnaire 6:** Blockchain technology for data security. This questionnaire was created after realizing the potential benefits that blockchain technology might bring to the IIoT in terms of data security. It targets a blockchain expert.

B.2 Questionnaire 1

General

1. Could you briefly present yourself and the role you hold within your company?
2. Could you briefly describe the importance of the supply chain management in your company?
3. Did you already start studying, planning or implementing IIoT solutions?

Production network and operations strategy

4. Could you describe how the IIoT may affect strategic decisions as the number of factories, their location and specialization (by product, market or technology)? Is relocating to low labor cost countries still valuable for an IIoT company?
5. Will there be a change in the logistic network (procurement and distribution routing) after considering IIoT solutions?
6. Regarding the operations strategy, will the company switch to a complete MTO model?

Sourcing and procurement

7. Will the IIoT affect sourcing decisions, such as the choice and number of suppliers, supplier relationship management or purchasing criteria?
8. Will the IIoT help the company reduce sourcing costs by bypass or vertical integration of suppliers?
9. Will the IIoT have an impact on the reordering method, such as fixed order quantity or periodic review systems?
10. How may sourcing and procurement generally be improved thanks to the IIoT and at what cost?

Sales

11. How may the IIoT affect the demand forecasting process of your company?
12. May the IIoT help automating sales processes that do not add value to the supply chain processes, such as the administrative burden, contract management and communication with the other departments?
13. How may the IIoT affect the customer relationship management (CRM) and after-sales service?
14. How may the sales and customer service department generally be improved thanks to the IIoT and at what cost?

Would you like to add any extra information to the content of our discussion?

B.3 Questionnaire 2

General

1. Could you briefly present yourself and the role you hold within your company?
2. Could you briefly describe the importance of the supply chain management in your company?
3. Did you already start studying, planning or implementing IIoT solutions?

Production

4. How would the factory layout be affected by a change of equipment after IIoT implementation?
5. Would the type of manufacturing (line, job-shop, by project) vary according to the IIoT?
6. Would planning method (such as S&OP, MPS or MRP) and software (e.g. ERP) be impacted or improved?

7. How may the manufacturing processes (execution and control) generally be improved thanks to the IIoT and at what cost?
8. Are lean strategies still relevant? Will flexible manufacturing be improved by IIoT solutions?
9. Will the IIoT have an impact on the environmental side of manufacturing processes?
10. How much will the IIoT affect manufacturing jobs?

Maintenance

11. Will the IIoT influence the design of the equipment? It may indeed predict its reliability, maintainability and availability in the frame of predictive maintenance.
12. May the IIoT improve the corrective maintenance efficacity?
13. May the IIoT help the equipment reduce their unproductive time and OEE?
14. How may the maintenance policies and processes generally be improved thanks to the IIoT and at what cost?

Would you like to add any extra information to the content of our discussion?

B.4 Questionnaire 3

General

1. Could you briefly present yourself and the role you hold within your company?
2. Could you briefly describe the importance of the supply chain management in your company?
3. Did you already start studying, planning or implementing IIoT solutions?

Product flows

4. Will the IIoT improve the product flows across the entire supply chain? If yes, how and at what cost?
5. What will be the impact on the product replenishment methods? Will the cooperation among supply chain members improve so that the ideal replenishment method can be applied?
6. Will the bullwhip effect still represent such a challenging issue?
7. What is, according to you, the perfect collaboration system to reach a replenishment accuracy that optimally matches the demand? Are the ECR and CPFR methods still used?

Warehousing and products handling

8. Is there an impact on the different inventories (cycle stock, security stock, pipeline stock or lot size inventory)? Will the IIoT reduce the different inventory costs?
9. Will the IIoT impact the factory's infrastructure (warehouse areas, stocking methods and handling equipment)? At what cost?
10. Will the IIoT influence the ways product are handled and moved within a warehouse (material stocking, picking, conditioning)?
11. Will there be an impact on the number of warehouses or logistic hubs for a single company?
12. Will the IIoT influence the decision of insourcing or outsourcing logistics and material handling?
13. Will the boundaries between companies still be as definite as without IIoT implementation?
14. How will the inventory and warehouse personnel be impacted by the IIoT?

Would you like to add any extra information to the content of our discussion?

B.5 Questionnaire 4

General

1. Could you briefly present yourself and the role you hold within your company?
2. Could you briefly describe the importance of the supply chain management in your company?
3. Did you already start studying, planning or implementing IIoT solutions?

Transportation

4. How will IIoT improve the transportation means and their wireless connection with other connected devices?
5. Will the IIoT affect transportation requiring a specific equipment (e.g. refrigerated trucks) or know-how (e.g. for dangerous merchandises).
6. How will the IIoT affect international transport and its heavy regulations?
7. International transportation requires the participation of many actors. Will the IIoT improve their collaboration? Are incoterms likely to change?
8. Will the IIoT affect transportation costs positively or negatively?
9. Will the IIoT bring new solutions to the overall performance of transportation? If yes, at what cost? For example, finding the best routing, maximizing tonnage and setting up continuous drives are current drivers of performance.
10. Will integrated software for transportation (e.g. TMS) be improved with IIoT solutions?
11. Will the carbon footprint of the different means be reduced? Will trains and ships keep their position as slow-moving but massified and greener transportation systems?

Reverse logistics

9. How may the IIoT improve the processes of reverse logistics, and at what cost?

10. How can we link the IIoT to circular economy?
11. Since the IIoT will amplify the number of customized products, will it be an additional challenge for firms that produce goods that are already rarely planned for reverse logistics?
12. Centralized return centers (CRC) are already trying to reduce their costs by automating processes. How can the IIoT help them in the process?

Would you like to add any extra information to the content of our discussion?

B.6 Questionnaire 5

General

1. Could you briefly present yourself and the role you hold within your organization?
2. Could you quickly describe the organization and its objectives?

The IIoT sphere

3. Do you have examples of companies that are in a process of studying, planning or implementing IIoT solutions? If yes, what are the results so far?
4. Could you briefly explain the IIoT, its technology and the main organizations working towards it nowadays?
5. According to you, what are the biggest drivers of the IIoT implementation within companies, and what are the main obstacles?
6. In your opinion, what does the IIoT want to achieve? Ultimately, is there a final stage or result we tend to?

IIoT and supply chain management

7. Will the IIoT further blur the boundaries within organizations? How will it affect cooperation among companies?
8. What are the impacts that will, for you, be the most consequent on supply chain management decisions, from the conception of a product to the supermarket shelf?
9. According to you, what categories within supply chain management will benefit the most from the IIoT?
10. How can we balance the costs and returns on investments of IIoT solutions?
11. Is the IIoT a luxury privilege that only big international companies can afford to invest in? What are the opportunities for the small companies and SMEs of the future?
12. How will the IIoT impact jobs and to what extent? Will there be new professions emerging from the change of industrial paradigm, just as informatics degrees for automation?
13. Some sources mention the IIoT as a purely marketing concept, rather than an industrial revolution. What do you think of this stance?

Would you like to add any extra information to the content of our discussion?

B.7 Questionnaire 6

General

1. Could you briefly present yourself and your freelance projects?
2. I am guessing that your expertise does not have anything to do with supply chain management or the internet of things. Is there any link between those fields, the blockchain or cryptocurrencies?

Blockchain

3. Could you briefly explain the blockchain, the disruption it might induce and its main advantages and drawbacks?

4. My thesis focuses on the industrial internet of things. One of the main challenges of this phenomenon concerns data security. How may the blockchain help companies be protected against external or even internal threats?

5. What can you tell me about the complexities of implementing blockchain solutions within a company (cost, complexity, legislation)?

Would you like to add any extra information to the content of our discussion?

Appendix C

Interview transcripts

Font type

- **Fat:** the student
- **Normal:** the interviewee

C.1 Expert I. Otto Schell: IIoT professional (oral interview)

Professions	Questionnaire	Date
- IIC: Partner - Opel Auto GmbH: SAP Architect - DSAG: IoT transformation	1. SC strategy, sales and purchases	July 5, 2018

I will give you a small introduction to who I am, so that you roughly know to whom you are talking to and why you get connected to me through the IIC. Should I start with the introduction?

Yes sure, feel free to start with this. You can introduce yourself and the company as well.

The IIC is, as you know, a consortium where different companies can take place; and I'm in the IIC playing the role of one of the vectors of the German speaking SAP user group. The SAP user group sounds like SAP with German speakers but it's not. In our community, we have 3400 companies which are all in the SAP ecosystem, with more than 180 subjects in its course, which are talking about bigger lines of business, processes for all industries, plus technology topics, plus support advices topics. Everything you can really think about the SAP ecosystem,

but as you may know, all the companies are having different integrated environments, it's not only focused on SAP. That is why when the IIC came, I joined because I'm running in this organization everything around IoT and business transformation. This is why I'm certainly a good interview partner, because I have a good overview of all industries. I know really good advices on where those industries are going, what's going on with IoT and what people are understanding. Regarding your questionnaires, you can pick what you want, I can go ahead. This interview will be under the umbrella of SAP.

In my profession, I am a global SAP business architect in the automotive industry, I run all the institutes for the digital transformation, I have two small companies running and I am a visiting lecturer at two universities. This week I have four interviews with special master's concerning their thesis, mainly in regard to blockchain and other technologies.

This interview is very valuable to me as my thesis is on the IIoT, so industrial internet of things. Of course, for me it is a bit confusing to be able to differentiate between the IIoT and industry 4.0 for example, even if I know that those movements have different origins, and maybe different purposes in some areas, but in a certain way, we can also gather them in a single industrial revolution, would you agree with that?

I think it is a waiting point, more philosophical. In the German environment we had in the 80's computer integrated manufacturing and it was similar to what we call today the industry 4.0, which means the idea to have just in time shop floor, we have some accords, we know when it gets produced and when it gets picked up. There are also some companies at this time which thrive, certainly with the technologies of the 80s. One thing that caused a lot of problems is, at the end, the question about what does it mean for the workforce? It was called the transparent fabric. Everybody feared the transparent fabric at that time. So when we called, in the European environment, industry 4.0, it is nothing else but, honestly, to be cautious with where does it go. In Germany, when we talk about industry 4.0, it is all about being proud of what we have achieved and how we produced, our engineering, our huge manufacturing companies which provide you the assets like Bosch or Siemens, but also so-called hidden champions in the midsized community, and what they wanted to avoid when they started this industry 4.0 is

"we need to come with the big picture, to scare people." Where you can see this very well is in some of the big fair, like the Hanover fair, which is in principle showing the frontier and where the movement goes, and this year was all about shop floor. Everybody felt very well, and I would say "guys, industry 4.0 is not bounded to shop floor or production, or logistic". IoT is much more. When you talk to me, it is really more than just the industry 4.0. When I talk to Chinese people, they are always very shocked because I talk to them as industry 0.1 because the difference between China, India or even Africa is that they don't have the historical package that we have, which explains the entire transformation of the community.

You think that for the scope of my thesis, which is about the IIoT, you would say, from your perspective, that there wouldn't be a problem if I mention the smart factories or cyber-physical systems into the scope of IIoT, if, of course, in the introduction of the thesis, I specify that I do not specifically differentiate between the industry 4.0 and the IIoT, for the scope of my thesis? I think for your thesis adding the word revolution is not really the right word, because everything is going in parallel at the moment. If you capture this under the umbrella, I call it, "sensor reboot processes", then you are there because we know that sensors will take a different role cooperatively with humans, we know that in a certain time, we get to the point where they order and do other stuff. So

I think that your direction, if it is allowed to do this in a thesis, in Germany thesis are always repetitive, but if you are allowed to have a future view I would fully support what you were just saying.

Ok, thank you very much for your respond, it is really helpful, at least in the organization of my thesis. So I have five different questionnaires, one of them is specifically designed for IIoT or industry 4.0 organization, but the others are more specific to the topic of my thesis. For example, one questionnaire about production and maintenance, another one on transportations and reverse logistics, another one on the product floor and the inventory, and finally a last one on supply chain strategic decision, such as sourcing, sales and operation strategy. So it would be very helpful if you could pick one of them.

You can pick what you need, and I always offer to students another session if they need to call

back or if what we talked about was not clear. So when you revise this interview, or if you are in shortage on some of the discussion, you can always call back.

Fantastic, thanks. What I would suggest is to maybe go through the first questionnaire today, and I will send you the questionnaire 5 via mail so you can answer it if you have time.

Yes, no worries.

Perfect! So, I will first you questions about strategic decisions and sourcing, procurement and sales. Have you ever started studying, planning or implementing IIoT solutions yourself?

So within DASG, we have a lot of companies which are working on pilots due to the fact that, as I mentioned, the processing environment we have, we've done a lot of optimization of processes through software like SAP or others, and know all of those companies, independent from the size, try really to find out what is IIoT, what is the impact and what are the opportunities going into future models. Then within our community, we have also, like the IIC has test beds, we have similar things. There are already companies which have transformed their current business model into the future, these companies are making proof of concept in specific areas, like in supply chain because it is very visible what you can do there. There are other companies, which are laid back a bit, "the books are full, why should I do something now?". There are a lot of different scenarios.

The main focus is really on shop floor, then the maintenance. One focus is coming up, of course supply chain, here it is more about transparency, predictive processes, so to understand when the trucks will be there and how many are there. There are good examples out in the market, like for specific harbor experiments, like the harbor of Hamburg in Germany or the harbor of Rotterdam, both done by different environment but the idea is that you cannot extend the harbor out of a limited area but the flows are increasing, so how do you optimize your supply chain. So for example, let's take a truck who knows where to go and he doesn't go into the harbor and block someone else's places. I think there are other examples, companies who try to make the

supply chain more transparent using IoT application. A typical example here are the container. It is a very important one because companies loose a lot of money because they don't know where the containers are. This is something where you see a lot of PoC. Sometimes also, in companies it is not really organized. What belongs to IoT is that you get global corporations and not a sided organization, but we still have sided organizations, every side does its own project on some of those evolutions.

So this is more about the harbours and the container management system?

Whatever you find, you will find it in the market as an example.

This is already a nice example that I can integrate in my work. I would like to talk a bit more about the production network and the operation strategy. I would be very interested in knowing how the IIoT, or the IoT may affect the number of factories and/or their location. For example, I am a company, I have a lot of distribution centers, I had my optimized decision, I would like to know if the IoT would have an impact on reducing or increasing the number of factories or impact their location, or even their specialization. For example, the factory could be in a certain place for lowering the cost, or for a certain technology or to be close to the market. So this is more about the factories location and purposes.

This depends on the view. Let's take a high-end view, the ultimate scenario would be that, digital twins exist. Let us assume you are looking up two different points of view. Let's take your smartphone. It is a hardware with a specific environment (we can also take another product or whatever, it could be a car etc.). Now imagine you have all the information about your smartphone available in the cloud, meaning the configuration, the content and the battery life of your smartphone. Having this on the cloud, as a so called digital twin, that you can work completely different with, with all other processes around. Now let's assume your smartphone goes from a horizontal position to a vertical position. The digital twin will see this and if you move it up, it will see it, and if it loose power, the digital twin will inform somebody "the smartphone has gone out of battery, put it on an energy button or bring somebody to the smartphone to plug it." For the moment, those processes either too late or people are trying to be predictive meaning the smartphone gives you a tone and you can go to the smartphone.

With the digital twin, it can be more aggressive in timing. At a certain point, as it is getting more intelligent, the smartphone will really order its own energy. It's a digital twin. So with this available, it doesn't matter where you produce anymore because it doesn't matter anymore where you take service, it doesn't matter anymore who does the service because you can put somebody in augmented reality on his isle and he could even do maintenance, not knowing what he is doing because he gets learnings and all of that kind of stuff.

So the message here is the combination of everything, it is not the IoT availability, the data, how we do procurement, the environment, it is the combination which makes the fun part out of it. And now with your mobile, you can imagine how long it will take to get to this digital twin. The next generation already has a lot of IA in, our mobiles also have a lot IA. They get smarter, but you cannot by all the time a new mobile. That is the issue with industry 4.0, there's a lot of old asset that you have to enable to get digital and hopefully you buy new assets which are digital. This is I think the real part of the transformation.

So you think that the fact of having a factory in Vietnam and another factory in Germany would cost the same in terms of, I'm not taking about labour here, I am taking about technology for example, so that the technology doesn't depend on the country where it is implemented?

I would turn this sentence here, at the end, if you have the same product in Vietnam and in Germany you know that you have the same product, well this information we don't have it at the moment. At the moment, to make an example, if you do something in Vietnam and in Germany, you have two plant managers, everybody does his best from his knowledge. But they cannot compare their assets, they don't even know they exist. One guy who wants a quality insurance, the other guy knows that the quality insurance is part of the contract and doesn't even pay for this, because you don't have the transparency. Then the current assets you don't have sensoring, which gives you information in a way that you can use. If the company decides that it's not mortal to produce in Vietnam or somewhere else, they don't know if the assets can be reused. As I mentioned, it is the combination of the different sectors, it is not one sector which makes it sexy, it is all of them.

Ok I see. I have a question about how the IoT can potentially change the logistic network, so directly from the factory to the client, to the market and will the company switch completely to a MTO model, because the forecast will not be needed anymore because if we have mass customization, we will directly start the production from the client's order to sales order, so that we won't need to make so many forecast anymore, what do you think about this?

I would say that you have to make a better forecast. The idea of individualization is not new, when you go into the car manufacturing, each car is a unique car, when you order a car you want something else than your neighbours. The question is, if you can shorten the supply chain, so put an order on a car, in whatever country, and if you have a specific wish, it takes you x months to get a car, because the order process is not linked to the sales process, not linked to the supply chain due to the fact you have specific processes. The processes as such takes less than 24 hours. So the question is why does it take so long from an order to production to the market and there are processes around which are part of the covenants which need to be changed. Technically, it is already possible what you have in mind, if you go to the US, to Harley Davidson, you can change your configuration 6 hours before they start to produce.

So this is late differentiation?

Yes, it is late differentiation, so if you have a nice bike in mind and you go there 6 hours before production, they will do it. If you do this in other manufacturing, they cannot because they have long lead times. Concerning your original question, it is more about working on those lead times to make it customer centric or consumer centric. At the end of the day, quite honestly, in my opinion, it is short term thinking because it is the way how we order now. But if you look in 10 to 20 years in the first smart connected cities, are you still thinking of buying a car? Of course not, and that it is the point, this means the IoT or industry 4.0 is also a sequence which may end up into a full convergence into a service organization.

So more about lending a service than actually lending the product itself but can be shared amongst different users.

Yes, certainly what we need to consider is 3d printing. 3d prints are getting better and better, so we have the opportunity to print material like steel or something else, than why do you need warehouses.

Yes it is very interesting, I didn't think about that, even thru my research. I would like to talk about the sourcing a little bit, I would like to know a bit more about what you think, about the different relation supplier management. Will the IIoT affect the choice or number of suppliers, or will companies bypass suppliers, by doing a vertical integration and take on the whole process, from the raw materials to the clients, what will happen to the supply?

What will really happen, we will go further from one relationship into network. For the moment, it is called supply chain, because it is a chain. If I want something from you, I make an order with you, the payments terms, than I go to a next one to have a backup, so in case you fail I have a backup. IN the future, this is already active, with SAP Ariba or other networks like Cooper or, at the end, what you do every day with Amazon or Alibaba, you order something even not knowing where or who is producing, you just order something on the specification and the quality behind. This means those networks will grow. People will rely more on getting the material on time and the quality or price of the material instead of having one on one relationship. When you go to the digital twin idea, you are not anymore really dependent. As I said, in the future, with 3d printing and other stuff, you can go out of specific dependencies. In certain industries, you have production stops mainly because of one or two suppliers which cannot deliver. This may change.

Then we will maybe find a small amount of big companies that will serve as markets for a lot of different companies out there using B2B markets, or do you think we will go towards something as a more competitive market? Or we will have giants, like Amazon, dealing with this?

I strongly believe that for the next five to ten years, the train is already gone, so Amazon or Alibaba, companies which are highly competitive in delivering, they will take over these markets. Every big industry has its own network, if Amazon would buy one or two of them, they will

be in the industry and they could then take their delivery models. Why can they do this, well they are already there. They are used to work in this environment. Why they are not doing this, maybe we don't know, because they are already doing it. Amazon, Alibaba, Google, some of the bi software companies, are already taking over by disrupting areas. Amazon for example, they are much more than a simple logistic company, they are a software provider. I strongly believe that a lot of people don't understand what IoT is and a lot of people are feeling safe for the moment because the books are full, and I strongly believe that a lot of people don't understand that there is no time to react anymore. At the moment, you may feel good, but at the moment you're hit, you don't have time to recover.

You mean as a specific company for example that is not interested in implementing IoT yet?

Yes, it is something that can move very very fast and to make sure it moves it has to be transparent and let people understand that technology is changing so fast that we will not follow after a moment.

Yes, this is why the German government is so interested in going fast and having an industrial policy that is quite aggressive towards, for example, data giants.

It looks aggressive to the outsiders, but internally, it is absolutely to slow because a couple of years ago, industry 4.0 was seen as an export meanwhile, other countries are much faster and Germany gets, ring after ring, below. It is very simple, they didn't really understand that it is not only talking about it, you need to take actions, not only to have networks which are fully equipped, we used to have a lot of records in Germany for connexion, but it is more than that, it is giving money to company with different sizes, to get pitched in. Just ask the upcoming colleagues of mine if they buy digital, if they procure digital, what they order right now, is this already digital equipped so that you can use as soon as they come in for new processes. The answer is often no, and so you know where we are standing.

So for example, via the interoperability of services?

Yes. Last week I was at a workshop of the first two companies I've seen which try to work together. So what they are doing is they take all their processes from the supply chain, so I order something and I get something and I pay something, so they take all those processes and they want to include blockchain into this. What they do is they bring all of those processes into the blockchain. Middlemen, like Banks, work with them and they don't say "we don't need this anymore" but they say "let's do this together". So these are the first signs that companies understand that this will also change their future business model.

Ok, I've a better idea on how companies will work in the future. I'll just go to the last topic of questionnaire 1, which concerns sales. So you already answered the question of forecasting, you said it was not about not having forecast but about having more precise forecast. My question would be, regarding sales, may the IIoT help automatize all the processes that do not add value to the supply chain process, because when we talk about of sales, we often think about administrative burdens, contract management, communication with the other departments because sales is connected with production, with inventory with even purchases in terms of raw materials, so my question is, will this integrate the process which do not add value?

Don't forget that the functions you talked about are still vital functions. Everybody, at the moment, see himself as important. Everybody understands the need for the digital but everybody works in a silo. Why do you need in the future a sales marketing department when you can anticipate, why do you need a dependency matrix between somebody doing sales, somebody doing marketing and then a material slept there because they didn't talk to supply chain. So what you have in mind is this kind of company dashboard which allows real time decision. You still need specific functions and specific skills, that does not change, but the way they talk together will be completely different in the future.

For example thanks to an ERP, SAP, Odoo,..

I would say thanks to intelligence, for exempla machine learning, artificial intelligence you can anticipate, you can read patterns and then on the patterns you can react, and due to the fact that successively for the next years, all the environments get more real time environment, thay

can act differently. You will never have a company which only runs, for example SAP, all the processes are integrated to their suppliers and their customers, that is the cloud solutions. At the moment they are not acting in sync, a lot of companies have for example ERP systems, like SAP, which are getting real time enabled but to get the interface out of your production, it is once a month, because they are so old. But in the next couple of years, when companies change this and turn their entire infrastructure, processes, systems and data in real time, then certainly you can act different within the company and its different areas.

So you think that ERPs still have a big role to play in the future of companies as well as the digital dashboard but they are not completely ready?

I would confirm but I would not put my hand in the fire if it's a premise solution or a cloud solution. But of course you need an orchestration background, of course you need to stick somewhere but this is something that we can also do differently.

Ok, this is very clear. I have a last question about customer service. How do you think that the IIoT will affect the relationship with the customer and the after-sales services?

In the charts I sent to you, there a picture called social architecture, so it's the relation between technology and humans, and I strongly believe that you need to differentiate here. When you produce something, I want to get the product to you, but you are not interesting for me as a product owner, you are interesting for me as a user of smartphone, which means I see you as a consumer and I want to catch you wherever I can catch you with my business. This means the IoT changes the relationship model. You mentioned something with one on one relationship product to consumer, so that you can differentiate and you can be proud that you bought something which nobody else has. The other question will be, how can I provide an end to end service with things that are not in my core portfolio.

So technically, the customer service must be much more precise in terms of the product that the customer has bought because his product is unique, right?

Yes, it is even stranger, if you go back to the digital twin then, if you buy a car or a smartphone, do you really want to buy or do you want a lease ? If there is a defect, do you want to call or

recall? If there is a defect, why do you need to call maintenance, maintenance should know that there is a defect. This means, on the other side, that you as a consumer, you open to a lot of people to get you data. I am somebody that always preaches that the data is already gone, so why do we talk about data protection? The question is how do we allow services around and how can humans at least know that somebody is picking this. For example if you have a smartphone localization service, you know that you are reachable, if you put it off, make sure that also the Bluetooth is off. For example, if you get a call, you want to know if it is AI or it is a human. If you'll get a call, but your phone will defect in two hours, we can see this because it is overheating, well we close your phone down and within 3 hours you'll get a new phone in your room, this is for me end to end service.

And this is something that could potentially happen. This is the trend we are going forward to in terms of customer service.

I hope it is the case.

Ok, thank you for your answers. Would you like to add more information to what we discussed?

In my environment, people start to understand where this is going, but are reluctant in sense of really attacking this, because we know that if we are not acting now, we will have issues in the future. I think that are a lot of companies that makes this very very well and a lot of governance which didn't understand that they are already taken over. I am somebody who wants to set very wide and open borders, so that we can do trial and error. What is happening is that it is new for everybody, it is new for professionals, for students, for all. At the end of the day, if we go digital nationwide, it is a positive move for everybody because it helps us a lot in terms of process breaks, which we have in companies, will be gone. For example, if you produce something and you take a part and put it from your company to another company which does a drill or something, gives it back to you: you lose your relations with the part, even if it comes back in a different bin. In the future, we will have blockchain, AI or other tools where all these process breaks will be gone. This is also helpful for the mentioned containers but also in crises like in Hawaii when there is an earthquake and you send materials there, it is always lost

because of corruption. For containers, you track it and you put a blockchain behind it so you know who use it. Those technologies can be seen in a positive way. As human, we don't have to fear it. There are tons of example in which AI helped make people move. It sounds scary, but it is important for us that we allow these new technologies.

I agree on that, you talked a lot about blockchain. What is, in your opinion, the relationship between blockchain and the IIoT?

So the blockchain will be a technology within IIoT. At the end of the day, you can use the internet protocol web semantic. So when you talk about supply chain, how do you follow your parts, how do you make sure that the bill of material is updated, how do you ensure that the invoice is done, so you have to know that it is stored somewhere, that somebody else looks at it, corrects it. You have specific areas with contract management, and you have abilities in blockchain which helps you get some of those process blocs solved. For me it is a vital part of IoT.

In the blockchain, everything is public because everything is decentralized, right?

Yes, but there are also different ways. You probably look at it from a bitcoin perspective, I look at it from a semantic perspective. You can also do blockchain between different partners. For example, the automotive company, they start to use blockchain for rental agreements. So you rent a car, with the rental agreement, you go also in other agreement, for procurement end to end, so your rental of the car is very safe. You can also use the commercial aspect of blockchain to pay in this environment. For this point of view, it is a vital part. Blockchain is a game changer to connect. There are not much people thinking about it. Some people are thinking about it, and their companies are working on it. There was a lot of blabla on the commercial side of it and how you can hack it. But if you have really hashtags with semantic behind it, which allows you to follow up and it is not changeable (the history), it is only adding (to the chain). It is really a nice tool to make your supply chain, even your own insurance, everything more accurate. If you talk about IoT, I would really suggest that you have a look in the impact of blockchains, so that you mention it and so that you also keep it in a context of helping, with the

characteristics of immutability, unchangeability and these kind of things, smart contracts, so it helps to streamline.

And at what node will the blockchain be in the supply chain? Will it be part of the network? The middleware? Or the software? I've read an article that mentioned all the different technological nodes of the IoT, and I wondered where would the blockchain be?

I would say what you mentioned. If you make a business with a third party, our blockchain would be in our network and it would go in a node, maybe we open a node for somebody else who joins. I really go away from the commercial perspective, and more about how do I create a trusted environment to allow cloud solutions? I need to protect my data.

Very interesting, thank you very much for your time.

C.2 Expert I. Otto Schell: IIoT professional (additional written answers)

Professions	**Questionnaire**	**Date**
- IIC: Partner - Opel Auto GmbH: SAP Architect - DSAG: IoT transformation	5. IIoT and I4.0 professionals	July 9, 2018

Do you have examples of companies that are in a process of studying, planning or implementing IIoT solutions?

Most of our member companies are in an awareness/assessment phase. Nevertheless, some are executing, mainly on shop floor areas.

Could you briefly explain the IIoT, its technology and the main organizations working towards it nowadays?

As discussed in the interview, typical examples as containerization and sensorics are practical and therefore interesting. High-end integration of IIoT solutions and E2E is still a way to go.

According to you, what are the biggest drivers of the IIoT implementation within companies and what are the main obstacles?

The biggest driver is the need to change and the benchmark with competition, so it's not really the pressure to survive, which I believe will come soon. The understanding of investments needed is the biggest obstacle.

In your opinion, what does the IIoT want to achieve? Ultimately, is there a final stage or result we tend to?

As mentioned in the first interview, it's all about connection and automation to get the best out of our resources and support human beings. IIoT and supply chain management

Will the IIoT further blur the boundaries within organizations? How will it affect cooperation among companies?

It will mantle down functional silos and strengthen E2E process automatization.

What are the impacts that will, for you, be the most consequent on supply chain management decisions, from the conception of a product to the supermarket shelf?

Considering the idea of "digital twins", entire flows will change, as well as an increase of human-machine cooperation.

How can we balance the costs and returns of investments of IIoT solutions?

With strong and long-term business cases.

Is the IIoT a luxury privilege that only big international companies can afford to invest in?

Clearly no. Business cases might be different, but it will impact all companies.

Some sources mention the IIoT as a purely marketing concept, rather than an industrial revolution. What do you think of this stance?

People who think this way will rather than sooner lose their "hidden champion" titles.

Would you like to add any extra information?

As mentioned in the previous interview, it is the combination of IIoT technology and business drivers who make the difference, not only the revolution of items.

C.3 Expert II. Karolin-Kristin Pellengahr: IIoT professional (written answers)

Profession	Questionnaire	Date
Fraunhofer IML: Scientific associate	5. IIoT and I4.0 professionals	July 11, 2018

Could you briefly present yourself and the role you hold within your organization?

I am a research associate at Fraunhofer Institute for Material Flow and Logistics (IML) since 2015. My specific research areas and responsibilities are procurement, logistic processes, supply chain management, digitalization and industry 4.0. Before Fraunhofer I worked 3 years for DB Schenker, a logistics forwarder and 1 year for Hella Automotive, an automotive supplier. I have a bachelor degree in business administration and a master of science in international management.

Could you quickly describe the organization and its objectives?

1. Fraunhofer-Gesellschaft:
    - the largest organization for applied research in Europe
    - 69 institutes and research units
    - 24,500 staff
    - € 2.1 billion annual research budget totaling. Of this sum, more than € 1.9 billion is generated through contract research

- Applied research is the foundation of our organization. We partner with companies to transform original ideas into innovations that benefit society and strengthen both the German and the European economy.

2. Fraunhofer IML:
    - 290 employees, 250 post grad students and student assistants
    - 30,7 million turnover, 50% of which from industry and commerce

Do you have examples of companies that are in a process of studying, planning or implementing IIoT solutions? If yes, what are the results so far?

1. Claas/ ekol/ Diebold Nixdorf: Research Project: Smart Contracts for Logistics and Farming (SOFIA)
    - Digitisation of Accounting- and transaction-systems
    - Equipment of logistic objects (containers) with decentralized control units (incl. sensors)
    - Blockchain infrastructure as a distributed, secure and valid data storage for event data
    - Analysis of strengths and weaknesses and selection of the most suitable Blockchain solution (Fabric/ Multichain/IOTA etc.)
    - Transformation: Conversion of business logic into Smart Contracts for automatic contract execution
    - Farming Use Case tracking harvesting process automatic contract monitoring automatic transaction via payment cloud
    - Duration: November 2015 - May 2019
2. Piel

- Development of cost-effective, safe and trustworthy Blockchain-based solution for the interface problem at PIEL
- Analysis of the actual situation and definition of requirements for the solution
- Development of a Blockchain-based data exchange process
- Evaluation of the solution from a technical and economic point of view
- Validation of the results by the Association of Technical Retailers
- Development of new business models by expanding the service portfolio
- Increase in own sales through new digital services
- Cost savings through cost-efficient, secure and trust-building Blockchain-based interfaces to Supply Chain Partners
- Planned: Sept. 2018 – Aug. 2019
- Call: "Industrie 4.0-Testumgebungen für KMU – I4KMU" - BMBF

3. Deutsche Telekom & Fraunhofer IML:
    - Deutsche Telekom and the Fraunhofer IML in Dortmund founded the »Telekom Open IoT Labs«. Six scientists from the Fraunhofer IML and three IoT experts from Telekom will jointly develop and test Internet of Things (IoT) solutions until it is ready for the market. The aim is to optimize processes in the manufacturing industry as well as the logistics and aviation industries.

Could you briefly explain the IIoT, its technology and the main organizations working towards it nowadays?

The Internet of Things is not a single technology. The IoT is now defined by the International Telecommunication Union as "the global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies."

The interrelated evolution of science, technology, business and social practices turns this vision into a reality. Algorithms and sensors offer a system of interconnected smart devices, which enable real time and intelligent communication from man to machine, machine to machine and enterprise to enterprise. IoT is a "general purpose technology" (Rousseau, 2017), it pervades many industries, improves rapidly and generates further innovations. More and more technology building blocks (e.g. smart objects and devices) that can be swiftly interfaced to create open or semi-open systems (Kortuem e.a., 2010, Serbanati e.a., 2011). These building blocks are continuously available at lower price and consume less energy. As the building blocks are increasingly used across all sectors, an increasing amount of data is produced and released and more value springs from connecting unrelated devices and capabilities. Data is becoming the most valuable raw material for the future. In other sectors, products are changed into product/service hybrids and business models are transformed. These changes 'who does what' and 'who gets what' within and across industries and new industry architectures emerge (Jacobides et al., 2006). (Source: IPSERA Paper 2018, M. Henke, H. Legenvre, H. Ruile, 2018)

There are no main organizations working on the topic of IoT. Research organisations, consulting companies, industry companies from numerous of areas, banking and insurance companies as well as universities, they all do research and projects within the area of IoT. 5. According to you, what are the biggest drivers of the IIoT implementation within companies, and what are the main obstacles? - Biggest Drivers: o Dynamic of markets o Rapid technology development o Competitive pressure o Simplification, automation and autonomy of processes in the long term o Meeting customer requirements much faster than today o Cost reduction - Main Obstacles: o Big knowledge gap o Execution within the company, the adaption to actual processes/ the implementation of new processes o The human factor is the critical factor o Financial restrains o The benefits of IoT and its technologies cannot be easily assessed or evaluated with numbers o High financial risks o Lack of imagination about future scenarios and possibilities given by IoT 6. In your opinion, what does the IIoT want to achieve? Ultimately, is there a final stage or result we tend to? - Achievements: o Autonomous processes o Stable processes o Shifting work to complex processes and important tasks. (Rest is done by IoT) o Raising customer satisfaction by real-time or same-day problem solving. o Direct connection and exchange with end customers

through IoT. o Learning quickly through immense data and information analysed by predictive analytic tools. o Strong networks and interfaces o Stable and rapid internet o Cost reduction (i.e. Smart Maintenance) o Prevention of production stops due to machine failure o Problems are immediately visible / are reported immediately and can therefore be resolved immediately. o Safe environments (no fraud, no attacks) - I guess that there will be a final stage of the IoT age, but the final result/its final stage (expressed in certain technologies and its advantages) is not predictable so far in detail. - Overall, we thrive to achieve a safe, errorless environment where things with things and people with things communicate, exchange information and processes run totally autonomous.

Will the IIoT further blur the boundaries within organizations? How will it affect cooperation among companies?

Yes I guess it will blur boundaries more and more for good.

IoT will bring departments and companies closer together. Tasks, processes and the communication will improve. (Less problem solving through highly autonomous and errorless networks.) People can focus on more important tasks (than trouble shooting), i.e. strategic relevant projects, future shaping projects. IoT overtakes all the daily problems and gives more space for relevant tasks, which will give more freedom to people for relevant questions. This in return will lead to a better work environment.

How can we balance the costs and returns on investments of IIoT solutions?

- Raising customer satisfaction by IoT will lead to more turnover per customer. (B2C)
- Raising customer satisfaction by IoT will lead to more contracts/ projects/ alliances and this in return to more turnover (B2B)
- Savings from personnel costs due to automation caused by IoT
- Selling knowledge instead of products and services.
- Selling not only products, but also the lifecycle service for this product which can be fulfilled by IoT.

Is the IIoT a luxury privilege that only big international companies can afford to invest in? What are the opportunities for the small companies and SMEs of the future?

Smaller companies might not be able to invest in the technology, but they can build business models that focus on all the new data that evolve through the massive new amount of data from IoT and the new data quality. They can offer new business models build on new information from IoT, evaluation data from IoT and give new information, predictive analytics and reliable forecasting. Companies can build new and unique algorithms to work IoT data in different ways and fulfill the needs of their customers. Software development

Because knowledge is key, SMEs and small companies can offer services where they try to submit knowledge about IoT to companies. Trainings, online trainings, books, academies, etc.

Because implementing IoT in companies is a change management project at the same time, companies can develop special trainings to not only deliver knowledge but also help companies that their employees accept new technologies and new tasks and processes immediately without big resistance.

How will the IIoT impact jobs and to what extent? Will there be new professions emerging from the change of industrial paradigm, just as informatics degrees for automation?

- IoT will impact jobs and tasks to a very extreme extent.
- Certain jobs will disappear, but at the same time new jobs will develop. Most overall, existing jobs and their tasks will change in the future.
- We will have completely new studies at universities or at least new major fields of studies. We will have new trainings and education programmes.
- Companies will send elder employees into early retirement programs because we need younger employees that grew up with the understanding of the internet and new technologies and their usage.
- Companies will develop their own education programs and will not only trust the government for education programs.

- Knowledge is key when it comes to new technologies. There will be people who implement IoT. People who work in the IT department nowadays, IT engineers or similar. They see IoT from a technical point of view and follow instructions from business and strategy. But also people working in business, management and sales have to evaluate all the technologies from a business point of view, they need to have a lot of knowledge and especially need knowledge about the advantages of different technologies and their independencies. Also they need the ability to evaluate the impact (also monetary) from technologies Is it worth it to invest in IoT? What is the return on invest?
- For the next decades we will have a lot of new jobs that relate strongly to the development and implementation of IoT. I guess that after the implementation of IoT and clear evidence that it runs smoothly and is reliable, companies will reduce their level of employees, because the ultimate goal of IoT is autonomy. After this you only need employees who understand the IoT very well and can control that everything runs well. I am also sure that after the IoT decade another industry revolution will come and there will be another shift and new job profiles will be needed.

Some sources mention the IIoT as a purely marketing concept, rather than an industrial revolution. What do you think of this stance?

Well everything in life is a constant flowing process where it's difficult to talk about certain boarders like the different stages of industrial revolution. So the term "industrial revolution" is difficult, because it did not come overnight. The "revolution" was prepared through several years before and the forgoing industrial stages. But of course, people try to cover the most important developments in life with big impact for humanity and industry. So people try to assign developments to certain time stages and that's why we have different industrial revolutionary stages. So yes, maybe the term "IoT" and also the term "Industry 4.0" are marketing terms. But in life we try to label everything and put everything in "boxes", that makes life easier to understand. Further we need the same understanding for the term "revolution" if we really want to evaluate if it's a real revolution or just a nice development (Incremental, iterative). My opinion: the step from the third to the fourth revolution is a big step for us and deserves the

term “revolution”. We build a whole new universe where people and things and machines can communicate, machines and things can control themselves, they work autonomous and they can learn from experience. This leads to a total shift from tasks for humanity. This will affect how people live totally.

C.4 Expert III. Pierre Semal: SCM researcher and professional (oral interview)

Profession	**Questionnaire**	**Date**
- Université Catholique de Louvain: Professor in SCM, OM and PM	4. Transportation and reverse logistics	July 13, 2018

We can start by discussing about transportation. Could you first describe your position and your role in this institution [UCL]?

I am a professor in supply chain management and I teach supply chain from a more strategic perspective than an operational one.

Did you already teach about IIoT and Industry 4.0 in your classes?

No, I’ve been teaching different subjects. The only thing I taught in this perspective is if using all these tools and software are adequate for a company. This is often a question that is key, it looks good and great but is it adequate? This requires a strategic analysis. Do I compete as a company and does this technology help me keeping my competitive advantage or at least my standards?

In your opinion, is it an advantage in terms of costs?

Well, in my opinion, if your focus on the minimal price, it will cost. If you implement a project in IT, you cannot implement a project on customer relationship or HR. Time is key. The job of the manager is not to use the right technology in the right place, it is to spend his time on the right problem. This varies from company to company. IoT and all these technologies is opportunity, and it has to be looked where this opportunity makes sense.

Everybody talks about Big data. Companies have data on sales for the last 20 years. Very few are able to manage them, to make a good forecast. There are techniques to make a good forecast, but it requires to clean and manage data, and so on and so on, but is it worth it? It is a good question. Companies like L'Oréal still have problems to make forecasts. Is it bad? I don't know, what they lose in terms of sales is so small that they can afford it. It is not only a question of cost, it is a question of time and a question of finding what is more important for your business. Cost is one thing. Time is another thing. It requires energy to implement a project. We see the technology, but we oversee the huge workload required to implement it. This is why many IT project also fail.

And it is very difficult to implement this technology factors into SMEs?

A solution could come from standardization. If you look at Microsoft, 30 years ago there was IBM, and then Microsoft made standard things like Word and made it available. I could imagine that the technology will bring standards and things like that. It could work, but you need little blocks that are easy to use and in a large scale so that the development is covered by the size of the market. Why is Word and Excel so cheap? Because it is spread in a large market.

Ok thank you. For you, how will the IoT affect the transportation means and the wireless connections between devices and the transportation?

IoT does already help for transportation. If someone is connected, they can reroute and have information, such as if someone is late. They can reuse capacity, etc. There are many opportunities, and definitely with dangerous goods, etc. Again, the question is standardization and make it work together. There is a problem that needs to be solved, which is the safety.

So you think we already have all the solutions?

Yes, you get information online, the troubles on the road, you have algorithms to optimize a route, you could decide to reroute automatically.

So you think IoT would not improve those solutions?

No, it can improve it, but the main question is safety in terms of, “am I sure that everything is being foreseen and it will not crash? ». Safety from the computer point of view means no one hacking the system and those kinds of things, IT robustness, and then there is the robustness of the solution by itself, do I have the right data about the people and to lead the decisions?

Do you think it integrates also the dimension of self-driving cars?

Yes, but it will take time. There are in some companies already AGVs (Automatic Guided vehicles), but only on a small scale. But it works in warehouses and factories.

What if someone hacks the route of a truck?

Most likely your Microsoft system is already hacked. I don’t believe you can avoid it, but you need a robust system so you don’t see a difference.

And how would it affect the international transports and the many regulations around it? Do you think it will ease these regulations?

For any system to work, you need to agree on a language. The problem with international software is the absence of common agreements. These tools must be used all over the world. How is data measured? If you define your standard and everybody use it, than you have leverage on the competition. So it is very competitive. Think about PC and Mac. So it is good to have RFID systems but you need to use it everywhere. GSM is global standard mobile. You can’t have a system like this if you don’t agree with other nations. It is very competitive. For IoT tools to be international, it needs the scale and a standard.

In analogy with ERP, SAP is a bit like a standard.

Alright thank you. So you think that the IoT will affect the cost of transportation in a positive way?

It will be implemented only if it makes sense. To see if it worthwhile, you just have to make a economical analysis. The world works with what makes sense, you make a move because you can win with this move.

Do you think that the IoT for transportation is the continuation of transportation management systems (TMS)?

Yes, it will evolve and grow. Everybody talks about revolution. The big change nowadays is that there will be independent agent taking decisions. Machines taking over humans is kind of a small revolution.

What criteria would you use to define « revolution »? I consider three criteria in my thesis, new technologies used, systematic change in social structures and in economic systems.

If it is one of the three yes, but the three at the same time, I don't think so. IBM could develop software, but Microsoft made everybody used it. That's more of an innovation.

How do you think it would be different for reverse logistics and the normal direction of logistics? It is said usually that reverse logistics are not equipped to deal with customized objects, because you need some kind of standardization to bring back parts and products to the company or the recycling plant.

I see the difficulties. Yes it will be customized, but again the customization will be made in a way that it is manageable in the forward flow. We have late differentiation and late customization, so why not apply it to reverse logistics by getting rid of customization first. But, again, the whole design is key here, more than the logistics itself. We will not recover something that is not meant to be recovered. You have to design it from the beginning, so it can be recyclable. The product itself must be designed in that purpose. You need to think of it from the beginning.

Ok, thank you very much.

C.5 Expert IV. Philippe Chevalier: SCM researcher and professional (oral interview)

Could you describe yourself and your role within n-Side?

Well I am the founder of the company and the chairman of the board.

Profession	**Questionnaire**	**Date**
- UCL (BE): Professor - CORE: Researcher - n-Side: President	3. Inventory and warehousing	July 19, 2018

And what is the importance of supply chain management within your company and did you already have to deal with the IoT technology and the industry 4.0?

Well yes, we've been working with supply chain problems quite a bit, specifically in the pharmaceutical area. Is there an influence of the internet of things? Well, everything must be registered and monitored for clinical trials for obvious traceability reasons. We are developing more the software to manage the data because with all these data, you kind of have sometimes data obesity, which means having so much data that it can not be digested and read to make better decision.

As a general question, would the IIoT improve the efficiency and the smoothness of the flows across the entire supply chain? This is of course the main objective of the industry 4.0. What do you think would be the main factors improving this efficiency?

I think the main factor would be related to risk management. In terms of flow of goods, the idea of IoT, you can track much more closely where the goods are. If there is a hurricane or a strike, or any kind of event, if you don't have precise information, you don't know if your goods are affected. When you don't know, it is hard to take a decision; if you know exactly what is the status, you can take the right action based on the information. That is the main impact.

So the risk will still be there but you can act on uncertainty.

Yes, in fact, there is no uncertainty anymore, you act based on information.

Specifically, on replenishment methods, do you think that the cooperation dynamics are different between my suppliers than without the IoT?

Yes, it is a facilitator, you get much more information. To manage inventory, if it is has to be done manually, it is harder for the client. It clearly reduces the cost to make inventory evaluation, so you would do it more often, continuously or from once a week to once a day.

Do you think somehow, we will still use systems like CPFR, or do you think that the IoT will implement its new systems in corporations?

I think that IoT will reduce the cost of doing things like CPFR, it is not a replacement but a an enabler. You can share information in a much easier way.

Do you think that ERP still have their place in the IoT setting?

Yes, you reduce uncertainty, you have more information, you can also reduce the overall inventory level. If you know that your inventory is almost empty and that the truck is nearby, you can already plan that the truck will go in bay four and tell the operator to put the priority on bay four. If you don't know, it makes things complicated.

We often talk about the modularity and the reconfigurability of modules within industry 4.0, do you think it enable instant changes of flows priority? For example, if we have an emergency order that we need to fulfil right now, and the supplier trucks are 20 minutes away with raw materials, we might need to change production priorities. Will it be very smooth, and will the configuration equipment reconfigure themselves according to these priorities?

Yes, once you have the information, you can be much more efficient. With the instant information, the problem is almost solved once you think about it. Otherwise you have to call the supplier, the warehouse, you have to wait to have the information, and you lose so much time that it is probably already on your floor.

And you mentioned the responsibilities of different actors, so you think that incoterms will still be present in future supply chains or there will not be any need for them since we can check on the shared platform the responsibility of an actor?

I am not very familiar with incoterms, but I think there is a traceability but there is still the notion of verifiability in which incoterms will be needed, according to the law and the contract. Even though you have all the information, sometimes thinks will go bad.

Do you still think that the bullwhip effect will still be a relevant dilemma within supply chains or will it be much reduced?

Some causes of the bullwhip effect, which are linked to the information, will be reduced, but some causes, which are not linked to information, like scarcity, promotion or competitive behaviour will not, in itself, be reduced. But having more information makes it easier, having for example some smart systems that can reduce the bullwhip effect, but you need the smart system.

When one member of the supply chain decides to deviate from the position that maximizes the supply chain surplus, by following his own interest, it messes with the whole supply chain performance.

Yes, people act in their self-interest, it is natural, it is even legal, you cannot force someone to act against their interest, I don't think it's the issue.

Ok, thanks. This question is more about the equipment, warehousing and product handling. Do you think their will be an influence on the different inventories or all the stocks will be maximized according to truck loading capacity, inventory capacity in every warehouse?

I don't think cycle stock will be affected, but safety stock on the other hand, because of less uncertainty we need less safety stock.

And pipeline stock inside the truck will be optimized?

Yes, but no real reasons for it to change.

Ok, thank you. What do you think may have an impact on the different warehouse infrastructure? Do you think the Industrial 4.0 will have a huge impact on the future of the factories, in terms of robotics and handling the equipment?

Yes clearly, we see that, soon, we will have autonomous cars on the street, so if you can have autonomous cars on this difficult environment, why wouldn't there be autonomous vehicles in warehouses? If you look at the job of an inventory picker in the warehouse, they will be replacement for these types of jobs, which nobody wants.

Will there be an impact on the number of warehouses within a single company and the number of logistics hubs that a certain company would have, like more vertical integration. Do you think that companies of the future will have a tendencies to vertically integrate their suppliers and B2B clients for example because they will think that this will increase their control over the whole supply chain?

Yes, I think that your last sentence explains why this won't happen. Why would a company want to stay integrated for having a better control? On the other hand, part of the control is due to information issues, if you can have the information, no need to integrate.

So you think that it is too early to say if most of the companies will try to specialize into specific niche production or integrate their partners?

I think companies will specialize and I think a clear example are companies like Amazon and Alibaba, which are doing only supply chain and are more efficient than others. You can be much more integrated in terms of your supply, produce the good, distribute the good and sell the good, those are three different things. Apple for example, they are not producing any computers, and they are one of the most innovative companies in the world without doing anything themselves.

Yes it is true. It raises the questions of the boundaries of a company, will they be as definite as they are today. Thank you very much.

About insourcing and outsourcing logistics, again, as you said I think some companies will specialize in supply chain and the arbitrage between outsourcing and insourcing will, maybe, not be the case in the future because companies will focus on their core business.

Yes, companies are focusing on their core business because of information. For producing our own bottle, it use to be difficult to find someone to produce the decoration for example. Today, it is easy to reach specialists instead of doing it myself, so I won't try to do the both.

Thank you. It is really beautiful to imagine a future where uncertainty is limited, but at what cost? Will it be beneficial for SMEs? In Germany, the industry 4.0 is focusing on SMEs and the IIoT from the IIC is focusing on big companies, so I was wondering about the cost and the price of all of this?

Well, if you can reduce waste because you reduce safety stock, it is a good saving. You have a better service and less waste. Of course the big thing related to that, is the revolution in energy. For example, the decrease of the price of a battery and solar energy. It is clear that in countries where you are sure to have enough sun every two or three days, it is much cheaper to produce your own electricity and forget about the grid. And the price of batteries and solar panels are decreasing. Soon, even in Belgium, it will be cheaper to produce your own electricity than connect to the grid.

Will small companies have the possibility to invest in such things?

Well the speed at which the price of electronics decrease, SMEs will be able to afford it. It is not only the price of energy and computing power which is going down, the price of sensors is going down as well. The price of all of this is going down so fast.

Perfect, thank you very much.

C.6 Expert V. Wassim Mbarki: SCM research assistant (written answers)

Profession	Questionnaire	Date
- GSK Pharma GmbH: Cold chain - LSM Kronos Chair: Researcher	Various	July 23, 2018

Could you describe how the IIoT may affect strategic decisions as the number of factories, their location and specialization (by product, market or technology)? Is relocating to low labor cost countries still valuable for an IIoT company?

With the transition toward the fourth industrial revolution and the implementation of intelligent production systems, the flexibility and efficiency level of unit of production will greatly improve. This could mean that asset specificity will not be a constraint anymore in the near future. As long as the technology in place is able to adapt to market or demand changes in almost

real time, we could imagine that companies will turn themselves more and more to mass customization strategy where offering highly personalized product to their customers would now be profitable.

Besides, recent technological advancements, like 3D printing, have considerably improve the capacity and flexibility of production equipment leading to less of it being needed to start manufacturing goods. Therefore, the easy accessibility to means of production should make room for smaller independent entrepreneurs to enter business. An important outcome of this phenomenon could be the scattering of production moving closer to the demand.

Finally, in the era of internet hyper-dependence, the relocation to low labor cost countries would not seem to be a great idea. Indeed, IoT technology requires a great infrastructure in terms of Information and Communication Technologies which is not characteristics of developing countries.

Regarding the operations strategy, will the company switch to a complete MTO model?

Smart factories will be able to adapt almost in real time to market, regulation, demand changes, thus I think that it would be pointless to produce to stock as future production systems will continually processed the data flowing through the value chain in order to optimize the production planning and reduce as much as possible the inventory cost. In conclusion, I do not think that literally every company will completely switch to MTO model (because some industries are stable and will still be easy to predict) but intelligent production system with the help of IoT and large amount of valuable data will optimize the operations of the firm and thus lower the cost of inventory while simultaneously improving client satisfaction level.

Will the IIoT have an impact on the environmental side of manufacturing processes?

Industry 4.0 could make sustainable business models viable in a fierce competitive landscape. This development could bring immense opportunities for more profitable and sustainable manufacturing.

It is pretty obvious to see how the fourth industrial revolution could contribute to the environmental dimension of sustainability. The shift towards smart factories allows for a more efficient

allocation of resources, materials, energy and water. Because of these opportunities for more responsible manufacturing, we can expect a rise in Sustainable business models as companies make use of the features of smart products and data to sell the functionality and accessibility of products instead of their ownership. Also, we can imagine how these technologies can be used to realize closed-loop product life cycles and industrial symbiosis.

How much will the IIoT affect manufacturing jobs?

Concerning the social dimension, with the increase in automation, many low-skilled laborers who performed simple and repetitive tasks could be redirected towards more meaningful jobs.

Do you have examples of companies that are in a process of studying, planning or implementing IIoT solutions? If yes, what are the results so far?

- Rolls Royce: Power by the hour
- Bosch Rexroth: smart factory
- SmartFactoryKL: The soap plant

Will the IIoT affect sourcing decisions, such as the choice and number of suppliers, supplier relationship management or purchasing criteria?

With the growing power and efficiency of future smart factories, we can see transaction costs for business operations dropping dramatically. It becomes less expensive and time consuming to obtain detailed data and information on each steps of a production process, identify suppliers' strengths and weaknesses or even customers demand patterns.

The decline in transactions costs could increase the ability to conduct business with more and different partners. This would mean that companies could have access to a larger range of business partners and simply connect with them to create and deliver value whenever and wherever necessary.

Let's not forget the fact that means of production are getting easier to obtain which means that small players could enter business and disrupt the business by locating themselves closer to the demand.

Therefore, we expect that the trend toward building strong business relationship will evolve to more opportunistic and timed partnerships. Partnerships with suppliers could be created and last long enough for a simple order to be delivered to the final customer.

Will the IIoT have an impact on the reordering method, such as fixed order quantity or periodic review systems?

With IoT and the continuous stream of data flowing between the client and the suppliers, reordering method will be autonomously managed and optimize by the intelligent production systems.

How may the IIoT affect the customer relationship management (CRM) and after-sales service?

In the Industry 4.0 landscape, factories will provide customers with what we called smart products. After delivery, smart products keep interacting with the manufacturer's production system. Thus, continuously collecting and sharing data with the system, the smart product could communicate the functional guidance to customers and transfer the uses feedback to the manufacturing system. It could go even further by giving advice of utilization based on the user's own behavior. With these new possibilities, a full production information log could be integrated with the product assisting smart factories in continuously improving the product design or predicting maintenance. What companies offer to their customers becomes more than just a product and really is a complete solution targeted to satisfy customer personal requirements.

The evolution to connected smart products could lead to the rise of new business models where selling the functionality and accessibility of a product instead of selling the ownership becomes more profitable for organizations. Then, the real added value becomes the services provided by the manufacturing firm rather than the tangible product.

C.7 Expert VI. Laurianne Solignac: SCM professional (oral interview)

Profession	Questionnaire	Date
TE Connectivity: Head of logistics	2. Production and maintenance	July 24, 2018

[AVANT-PROPOS]

[Explication de l'IIOT]

Je voulais savoir si vous aviez de bon outputs, compte tenu de votre expérience, concernant la production et l'influence de l'IIoT dans celle-ci ?

Alors oui, j'ai une expérience de trois ans dans l'industrie, mais je ne gérais pas la partie production, je travaillais avec eux.

Donc vous vous êtes concentré sur quel domaine en travaillant dans l'industrie ?

Réception, magasinage, mise à disposition des pièces pour la production, expédition et enfin transport.

Donc tout ce qui est aval et amont mais pas tout ce qui est à l'intérieur de l'entreprise ?

Oui exactement. J'ai implémenté SAP aussi, donc j'ai beaucoup travaillé avec la production.

[FIN AVANT-PROPOS]

Est-ce que vous pouvez vous présenter très rapidement et expliquer votre rôle au sein de l'entreprise ?

Alors je m'appelle Laurianne Solignac, je suis responsable logistique au sein de TE-Connectivity, à Allonnes.

Est-ce que vous pourriez brièvement décrire l'importance de la supply chain dans cette société ?

La supply chain, c'est très très large, c'est la colonne vertébrale de l'usine, ce n'est pas possible de travailler sans puisque cela englobe tout, du sourcing à la gestion logistique en passant par

la production. Au final, c'est ce qui nous permet de fabriquer un produit et de le vendre à nos clients. Si on prend les choses séparément, la logistique c'est l'endroit où je travaille le plus, c'est un service de support qui est indispensable et qui doit, justement, se mettre au service de la production pour pouvoir attirer ton client en temps et en heure.

Et quelle place prend la production et même la maintenance dans la société ? Est-ce que cette dernière est importante ?

C'est comme pour tous les services. On considère que c'est un service support, mais si ce n'est pas géré correctement, il y a des conséquences sur le côté. Une machine en production qui ne fonctionne plus va décaler tous les plannings. Donc la maintenance c'est primordial. Ça coute plus cher de bien maintenir des appareils (dans un instant T), mais au final sur le long terme, ça augmente ta productivité.

Est-ce que vous aviez déjà entendu parler des solutions IIoT auparavant ?

Non, tu es le premier à m'en parler. Quels outils est-ce que cela comprend, RFID, ... ?

Alors, RFID c'est un point clé technologique de l'IIoT. Il y a beaucoup de nouvelles technologies, ça forme un tout, on appelle ça un système cyber-physique qui regroupe des éléments techniques comme les softwares, les hardwares (les puces RFID, des équipements qui bougent grâce à l'intelligence artificielle, ça va rendre la production très flexible).

Ce type de technologie n'est pas applicable à tout. Là on parle d'industrie de production de masse. Où je travaille, sur la partie ferroviaire, on fabrique des connecteurs, ce sont des produits assez récurrents, donc ce sont des choses sur lesquels on peut peut-être appliquer ce genre de technologie, même si au final on ne produit pas ça en masse et ça coute assez cher. Nous on a une autre partie pour tous ce qui est plateforme pétrolière, l'autre problème qu'il y a c'est que pour ce genre de projet, ce sont pratiquement des connecteurs sur-mesure, pas plus de trois fois la même pièce, donc on ne peut pas appliquer ce genre de technologie là-dessus. Après, pour tout ce qui est automobile et tout ce qui est fabrication d'électroménager, c'est quelque chose qui existe déjà mais qui est perfectible.

En fait, il n'y a que très peu d'usines industrie 4.0, toutes au statut embryonnaire. En fait, le but de l'industrie 4.0, c'est de faire de la customisation de masse, c'est-à-dire de produire des lots uniques pour le même coût et la même vitesse que la production de masse. Donc augmenter la productivité et la flexibilité. Les machines doivent pouvoir parler le même langage pour pouvoir s'adapter rapidement. Cela s'appelle l'interopérabilité sémantique des données.

Ah parfait, je comprends mieux le contexte.

Est-ce que vous savez comment le lay-out d'une usine de production pourra être affectée par ce genre de technologie ?

Suppression de poste, réduction des coûts, augmentation des marges, de la clientèle, ça a beaucoup d'impacts différents. C'est un gain de temps et de productivité, et donc d'argent. Les trois piliers (coût, productivité et qualité) de la supply chain sont améliorés. Mais après, en retirant un technicien, il va falloir tout de même recruter un employé avec un diplôme d'enseignement supérieur pour gérer ce genre de technologie. Donc il y aura moins d'employés, mais l'entreprise aurait besoin d'un employé qui coutera plus cher.

D'ailleurs, cela me fait penser à quelque chose. J'ai mis en place des kardex au sein de TE-connectivity, c'est-à-dire des plateaux sur lesquels il est possible de stocker des pièces et de les faire descendre automatiquement si besoin. C'est un gain de place et de temps, puisque l'opérateur est juste devant son kardex. Nous voulions le mettre en lien avec SAP parce que les opérateurs étaient obligés de se connecter à l'interface du kardex, et non à l'ERP, pour faire descendre les plateaux avec les pièces requises. Donc mettre ça en lien directement avec SAP aurait facilité les choses et entrainé un gain de temps. C'est plus au niveau de la gestion des stocks, mais c'est lié à la production.

Vous répondez en partie à ma prochaine question : est-ce les méthodes de plannings comme S&OP, MPS ou ERP vont être impactés positivement par la technologie IIoT ?

Ah oui complètement, il faut faire le lien avec une ERP lorsqu'on implémente cette technologie.

Et évidemment cela impacte la pyramide de l'automation.

[Explication de la pyramide de l'automation]

Oui, la plupart des problèmes dans les entreprises ce qu'elles font les choses au fur et à mesure et finalement, il n'y a pas de système global qui lie tout, le lien entre les différents piliers est très important.

Oui, cette interopérabilité est d'une importance capitale, et c'est justement l'un des challenges de l'industrie 4.0.

Dans ma société, j'ai dû utiliser un autre satellite de SAP pour la partie transport et expédition. Du coup, je devais baser avec une autre équipe technique basée en Allemagne, et ils avaient l'habitude donc il y avait un lien qui était créé, ce qui entrainait un gain de temps. De toute façon, un ERP à une base et plein de satellite autour. On ne travaille pas directement dans notre ERP. Ces satellites sont des différents systèmes connectés à l'ERP.

Est-ce que vous ne pensez pas que l'on pourrait avoir des avantages des technologies 4.0 sur une type de fabrication projet ?

Je ne pense pas parce que cela couterait trop cher pour faire paramétrer le système à un projet spécifique. C'est déjà tellement compliqué au niveau de la logistique. Pour mon projet, quand j'ai implémenté SAP, cela ne ressemblait plus au SAP de base, on aurait dit deux programmes différents. J'ai dû travailler avec des consultants pour développer la partie projet dans SAP parce que le service de base n'était pas adaptable. Toutes nouvelles technologies pour les projets est spécifique au projet. Je ne pense pas que l'utilisation de technologie 4.0 serait un gain de temps ou d'argent dans ce cas-ci.

Et plutôt en termes d'efficacité d'organisation dans les projets ?

Non, ce n'est pas possible. Après avoir travaillé avec un client et établi un cahier de charge et réalisé les premiers tests, si on se rend compte que quelque chose que, par exemple j'ai imaginé, ne va pas, nous sommes obligés d'enlever une des pièces du connecteur testé. Cette pièce-là a été commandée qu'en une seule fois, puisqu'elle est chère, et on travaille en MTO dans le cadre d'un projet. Donc on est obligé de réapprovisionner une autre pièce pour refaire des tests. C'est

bien trop particulier pour pouvoir implémenter ce genre de technologie, puisqu'on ne produit pas en masse.

A votre avis, est-ce que les stratégies de lean manufacturing sont toujours cohérentes dans le contexte de l'industrie 4.0 ?

Oui c'est une stratégie d'amélioration, d'ailleurs je trouve que lean management ça veut tout dire, c'est un terme très général. Les nouvelles technologies vont juste se mettre au service de la stratégie d'amélioration de la productivité et de l'efficacité. Le lean management c'est un outil d'amélioration, et la technologie ne va pas l'affecter négativement. Ça va venir aider à atteindre des objectifs.

Comment pensez-vous que ces technologies vont affecter le marché de l'emploi ?

Toutes les avancées technologiques vont faire en sorte que les gens moins qualifiés vont avoir des difficultés pour trouver du travail, même si au niveau des PME et des marchés de niche, l'implémentation de cette technologie sera peut-être trop couteuse, mais surtout au niveau de la production automobile et la production de masse. Les salariés vont devenir de plus en plus qualifiés.

Parfait, merci. Je vais un maintenant aborder un peu la maintenance, corrective et préventive. Est-ce que les technologies IIoT vont impacter le design d'un équipement pour réduire les opérations de maintenance par la suite ?

Oui, je pense. Surtout dans le curatif. Après, cela reste une machine, c'est difficile de qualifier le temps de maintenance. Il faudrait demander à un profil de technicien. Mais je pense que l'impact serait différent, le temps de maintenance peut être réduit. La rapidité de réponse pour une maintenance curative peut être améliorée, cela permettrait de mieux s'organiser. Ce type de système peut aussi te permettre d'avoir beaucoup plus d'information sur ta machine et de faire disparaitre les pannes des machines. Ça peut être clairement positif.

Parfait merci beaucoup.

C.8 Expert VII. Julien Destabelle: blockchain analyst (oral interview)

Profession	Questionnaire	Date
Freelance: blockchain specialist	6. Blockchain	July 25, 2018

Pouvez-vous brièvement vous présenter et présenter vos différents projets en tant que Freelance en cryptocurrency?

Et bien je suis trader en ligne dans le domaine des cryptomonnaies depuis maintenant 4 ans et demi. Comme projet, j'ai différent site web d'information qui parle de la technologie Blockchain et de la révolution qu'elle risque d'amener dans les prochaines années.

Parfait, merci. Donc je suppose que votre expertise n'a rien à avoir avec le supply chain management ou l'internet des objets, sur lequel je réalise mon mémoire. Est-ce vous avez une idée du lien qu'il pourrait y avoir entre la blockchain, les cryptomonnaies et le domaine global du management ?

Dans le domaine du management, pas trop. Il y aura plutôt un impact sur tous ce qui est IT, comme l'optimisation des bases de données actuelles. Ça ne va pas vraiment aider au management humain. Ça pourrait aider à la coopération entre les entreprises, en leur permettant, par exemple, d'avoir des bases de données partagées, dans lesquelles elles mettent toutes des données et elles ont toutes accès à ces données, en sachant que les autres entreprises ont respecté certaines règles en accédant à la base de données.

Donc ça me permet de mettre des liens directs avec l'IoT, vu que la coopération des entreprises va être améliorer grâce à l'IoT. Il y aura évidemment tout une notion de confiance et de sécurité des données qui vont probablement être compliquées à mettre en place, mais cela reste très intéressant. Est-ce que vous pourriez brièvement expliquer la blockchain, le choc social et économique que cela pourrait apporter, ses avantages principaux et ses défauts ?

Pas de problème. Alors la blockchain est une technologie de base de données. Les bases de données sont des gros stockages d'informations bien classés pour faciliter l'accès à ces informations. La blockchain c'est une base de données qui respecte obligatoirement certaines règles pour que les participants puissent entrer ou sortir des données de cette base de données. Par exemple, un des avantages de la blockchain est le fait que l'on peut avoir confiance dans les données qui sont entrées dans la base de données, même si, dans le domaine des entreprises, c'est une entreprise tierce qui a entré ces données. Cela permet aux entreprises, qui au départ n'avaient pas de relation de confiance entre elles, d'en établir une sur des données, éventuellement sur leur stock, leurs clients, sur différents types d'informations.

Il y a aussi des inconvénients. C'est en général plus lent, en tout cas avec la technologie actuelle, c'est plus complexe à mettre en œuvre, aujourd'hui en tout cas. Il y a peu de personnes capables de travailler sur cette technologie.

Cela demande un certain niveau d'expertise ?

Oui exactement.

Et vous m'avez dit plus lent, à quel niveau ?

En fait, le fait que la base de données ne soit pas stockée à un seul endroit, donc décentralisé, pour la plupart des blockchains, fait en sorte que les différentes « nodes » (nœuds) qui partagent cette base de données doivent se synchroniser entre elles pour pouvoir communiquer. Donc c'est entre 3 à 4 fois plus lent qu'une base de données centralisée classique.

Ok, et les différents nœuds sont répertoriés selon tous les utilisateurs de la blockchain ?

Oui, c'est-à-dire que chaque nœud connait un grand nombre de nœuds qui sont autour de lui, et lorsque l'on fait la somme de tous les nœuds, ils savent tous quels nœuds font partis du réseau.

Et à partir de quel moment est-ce que mon PC est utilisé comme un nœud ?

Et bien, on pourrait imaginer une blockchain entre les différents mémorants, ou chaque mémorant aurait un nœud sur son ordinateur. A chaque fois qu'un mémorant ajoute une entrée sur la base de données, chaque autre nœud sur chaque ordinateur des autres mémorants va regarder

la nouvelle entrée dans la base de données et juge “est-ce que cette entrée est valide, est-ce qu’elle correspond aux critères établis pour cette blockchain, est-ce qu’elle est, par exemple, bien constituée de textes, uniquement en anglais, et est-ce qu’elle est bien signée par la clé du mémorant ?”

En double entrée c’est ça ?

Oui, il y a un système de double entrée, de double clé pour la structure. Mais ce n’est pas très important, c’est de la cryptographie, il y en a partout sur internet. La cryptographie, dans les cryptomonnaies, c’est vraiment un détail.

Super, merci pour votre réponse. Dans mon mémoire, je me focalise sur l’internet des objets industriels. L’un des aspects les plus importants dans cette technologie est la sécurité des données et peut-être leur appartenance aussi, dans le sens où l’on ne sait pas exactement à qui va appartenir les données. Si nous avons des données qui sont partagées dans un écosystème d’entreprises, de clients et de suppliers, est-ce que nous pouvons encore dire que les données sont... est-ce que vous connaissez le système de digital twin ? Donc imaginons que vous êtes mon client, je vais vous donner mon produit, vous allez encore vendre cela à plusieurs personnes, vous allez donc avoir la propriété physique du bien à partir du moment où vous l’avez payé. Maintenant, à partir du moment où ce produit a un digital twin, c’est-à-dire que vous avez une copie digitale de ce produit, sur une base de données, connectée à un ERP par exemple, on va pouvoir avoir la représentation digitale du produit sur le réseau, sur un cloud. Donc par exemple, si un objet passe en position verticale, le digital twin va aussi passer en position verticale. Cela permet d’agir directement dès qu’il y a un problème, comme par exemple un coup reçu sur le produit, le digital twin va lui aussi recevoir un coup. Cette information va donc être directement donnée au département maintenance qui va pouvoir intervenir en conséquence.

Donc maintenant, que se passe t’il lorsque le supplier est responsable pour la sécurité du produit, par exemple, à qui appartient l’information ?

Avec la blockchain, on peut compartimenter l’accès à certaines informations présentes sur la

base de données. On peut dire que certains acteurs partagent certaines informations sur la base de données mais ne donnent l'accès à ces informations qu'à des acteurs spécifiques, voir juste à eux seul. Ils peuvent stocker de manière privée des données dans une blockchain qui est au final publique, grâce à la cryptographie.

Ok, et en termes de la sécurité ? En quoi est-ce que la blockchain peut assurer le fait de ne pas se faire hacker par exemple ?

Il y a deux choses, au niveau de la sécurité, qui sont assez sympas avec la blockchain c'est que, d'une part, comme je viens de le préciser, on peut compartimenter l'accès aux informations qui sont dans la base de données. C'est-à-dire, par exemple, pour un site d'informations en ligne où il y aurait des comptes pour chaque client, chaque client pourrait définir une politique de confidentialité très stricte qui ferait en sorte que, même l'entreprise chez laquelle il est inscrit sur le site web, n'a pas accès aux données qu'il a entrées, sauf s'il leur donne clairement accès à telle ou telle partie de ces données. C'est-à-dire que la société stockerait ses données, mais n'y aurait pas accès. A ce niveau-là, un hackeur, qui essayerait d'accéder à la base de données de cette entreprise n'aurait pas accès aux informations de ses clients qui auraient activés la politique de confidentialité plus stricte. En fait, le hacker aurait accès aux informations mais cryptées, il ne pourrait pas les lire parce qu'il n'aurait pas les clés d'identification des clients. Donc la seule façon d'hacker cette politique de confidentialité ce serait d'aller voir le client lui-même. Oui, il faudrait attaquer chaque client séparément. Et même s'il arrivait à menacer un client avec un revolver, le client ne pourrait que donner ses données mais pas celles des autres.

Donc ça pourrait résoudre le problème des hackages collectifs ? imaginons, on a un ERP qui contient les informations des clients, des suppliers, des partenaires, etc... un ERP qui n'est pas sécurisé assez, à partir du moment où il se fait hacker, toutes les données sont exposées.

Oui. On pourrait avoir une sécurité à clé multiple avec par exemple, l'autorisation des trois plus hautes fonctions de la société pour ouvrir l'accès à la base de données complète. Donc on aurait des données cryptées uniquement pour l'entreprise mais qui serait décryptable si, au moins trois

haut dirigeant de l'entreprise donnent leur accord. C'est très difficile pour qu'un hackeur mette la main sur ces données.

Surtout qu'on pourrait désigner quelqu'un qui n'est pas le chef de l'entreprise, un tier de confiance qui serait charger de garder la clé et de la donner en cas de besoin. Tout cela avec un accès compartimenter, où un employé lambda pourrait accéder aux données de ses clients.

Il y a aussi le côté incorruptible des bases de données de type blockchain. C'est le deuxième avantage. Une base de données de type blockchain, une fois qu'on y a entré des données, on ne peut pas modifier ces données sans que cela ne laisse une trace. C'est-à-dire, il ne peut pas y avoir d'action sur les données qui ne soient pas directement visible par tous les acteurs. La technicalité est assez difficile à expliquer, mais en gros, chaque block de la blockchain comprend une trace des blocks précédents. Donc si un acteur malveillant veut modifier une information dans la base de données, une information qui a été entrée il y a quelques heures, l'acteur malveillant devrait retourner dans le passé changer le bloc et tous les blocs suivants. Les blocs sont dépendants les uns des autres. C'est incorruptible.

J'ai lire à propose d'un troisième avantage de la blockchain, l'inchangeabilité ?

Oui, ça rejoint l'incorruptibilité, il est impossible de changer les données sans que cela soit visible par les autres acteurs de la blockchain.

Mais techniquement, il y aurait moyen de changer les données ?

Oui, il y a moyen, mais ce serait visible, donc il n'y a pas moyen de faire ça ... discrètement.

Ok super, merci beaucoup pour ces informations. Que pouvez-vous me dire sur la complexité d'implémentation d'une blockchain, par exemple dans une société, et combien coute au final une implémentation de blockchain ?

C'est assez complexe car très peu d'entreprises ont déjà essayé cette technologie. De plus, le nombre de techniciens informatiques capables de faire cela est très réduit. Le coût va donc être très élevé. Surtout qu'il n'y a pas de précédents, donc les informaticiens qui seraient devant le

problème n'auraient aucun travail précédent sur lequel se baser, ils doivent donc faire appel à leur créativité et partir de zéro.

Dans le cas de créer une nouvelle blockchain ? Sans utiliser une blockchain préexistante ? Dans le cadre d 'une entreprise, il serait dangereux d'utiliser le second cas…

Une blockchain privée serait surement utilisée dans le cadre d'une entreprise, mais il y a très peu de blockchains privées et les sociétés qui les ont créées gardent jalousement les secrets de leur technologie.

Et avez-vous une idée des différentes facettes du coût d'une blockchain ?

Au niveau infrastructure hardware, ça ne doit pas couter grand-chose, c'est très semblable aux bases de données classiques. Ce sera surtout au niveau des techniciens, qui feront opérer les changements dans la structure de fonctionnement de l'informatique de l'entreprise, ç'est là que ça va être couteux.

Il faut vraiment une personne qui soit responsable de cela et qui soit disponible 24h/24h pour gérer la maintenance de la blockchain ?

Oui, voir même plusieurs personnes pour le développement d'un système pareil.

Parfait, merci beaucoup. Est-ce que vous avez autre chose à rajouter dans l'impact de la blockchain ?

Et bien c'est une technologie qui me passionne. Je pense que l'on est encore très tôt dans la révolution que cette technologie va apporter à mon avis, les applications sont encore très réduites, on y va encore un peu par tâtonnement, un peu comme au début d'internet. Mais c'est un outil qui va nous permettre de construire des choses intéressantes.

Parfait, merci beaucoup pour vos réponses !