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The Industrial Internet in Finland: on route to success?

Edited by Maarit Tihinen & Jukka Kääriäinen

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The Industrial Internet in Finland: on route to success?

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Preface

Digitalisation and Industrial Internet have become buzzwords that are used in many situations as umbrella terms for new business opportunities in which emergent digital technologies are exploited. Since these terms are considerably broad, it is necessary to conduct research on related topics, first to construct a framework in which to discuss the issues, and second to define the specific problems therein. This publication provides such a framework by defining the central concepts and depicting use cases, especially in terms of how information technology (IT) firms view the digital world of the future. These efforts are supported by the results of a study on how a chosen set of companies have seen their operating environment, business and operations transform due to digitalisation.

One characteristic of digitalisation appears to be that it is a moving target, meaning that business opportunities lie in attaining the right combination of technologies. But what might such a combination involve? Is it the use of sensors in a value chain; the data these sensors provide; or the opportunity to understand the value chain more deeply? An IT company is required to rethink its role when building up its business. Traditional IT offerings are no longer enough; successful digital transformation requires changes to both mindset and culture. Case by case, we are seeing innovative solutions to resolving customers' problems.

The use cases in this publication are crystallisations of the challenges and how companies deal with them using their evolving roadmaps. The two necessary questions to address with such a roadmap are what kind of technological choices can be used, and where does the value come from, within a reasonable timeframe? The use case companies in this publication are frontrunners; their experiences will bring value to the readers in the form of tangible examples. In the near future (within three years), as our questionnaire studies show, almost a third (68%) of those respondents whose companies had not yet exploited the possibilities of the Industrial Internet, expect to perform investments within that area.

As digitalisation takes hold in the industry, the need to understand the challenges of the future in a systematic and analytical manner becomes evident. A corpus of use cases, and our quantitative research, reveals the required steps to generalise the approach to understanding digitalisation as a phenomenon, and its impact. By doing this, we will be better placed to provide normative instructions. Eventually, using a systematic approach, we will be able to foresee the possible disruptive

impact that digitalisation may have on a company's operating environment, and how this can be turned into something positive. One thing is certain; we cannot hide from digitalisation and the ongoing transformation it entails. The best strategy is to be vigilant and make sure we remain on the pathway to success.

This publication presents the key outcomes of the TINTTI project (IT Houses to Boost Industrial Internet), which was conducted from 2015 to 2016. The publication includes an analysis of the state of the art technologies and practices relating to business development, as well as the industrial needs and opportunities surrounding the Industrial Internet. In addition, it introduces a digital transformation model that will facilitate companies to be more aware of the development of digitalisation within their own sector and be better prepared for the changes required by digitalisation in terms of its' particular business operations.

The authors wish to thank Tekes – the Finnish Funding Agency for Innovation, for its support of the TINTTI project.

Contents

1. Introduction

The digital transformation manifests itself in the Industrial Internet in the domains including manufacturing, process, energy and transportation. It systematically applies sensor, communication and data analysis technologies, and empowers people with real-time information so they can improve their productivity and take advantage of new opportunities. While existing processes can be made more efficient using the new technologies, digitalisation also opens the door for innovative business models, many of which involve services in addition to product-based business, or even instead of it.

Clear definitions for key terms in the field, such as digitalisation, digital transformation and Industrial Internet, are needed to enable a meaningful discussion. We will therefore look at these terms in more detail now. Digitalisation is thought to be a more fundamental change than just the digitisation of existing processes or work products. The term refers to “the action or process of digitising; the conversion of analogue data (esp., in later use, images, video and text) into digital form”. In this publication, *digital transformation* is defined as a change to models of working, roles and business offerings, occasioned by the adoption of digital technologies by an organisation or its operating environment. This refers to changes at several levels: process, organisational, business domain and societal. It involves a change in leadership, different thinking, the encouragement of innovation and new business models, the incorporation of digitisation of assets and an increased use of technology to improve the experience of the organisation’s employees, customers, suppliers, partners and stakeholders (Parviainen et al. 2016).

The following definition for *Industrial Internet* is used in this publication: the Industrial Internet automates and rationalises operations, as well as enabling new business by connecting intelligent machines, equipment, users and organisations so that decision-making can be improved through the use of advanced data-analytical methods (Tihinen et al. 2016).

Although ICT technologies have been around for quite some time, what fundamentally distinguishes the current digitalisation phenomenon from earlier modes of automation and rationalisation is the scalable nature of the networks, both from data and business perspectives, which is enabled by dramatically improved communication, computing and data management capability – all of which is brought about by the internet. This development is depicted in Figure 1.

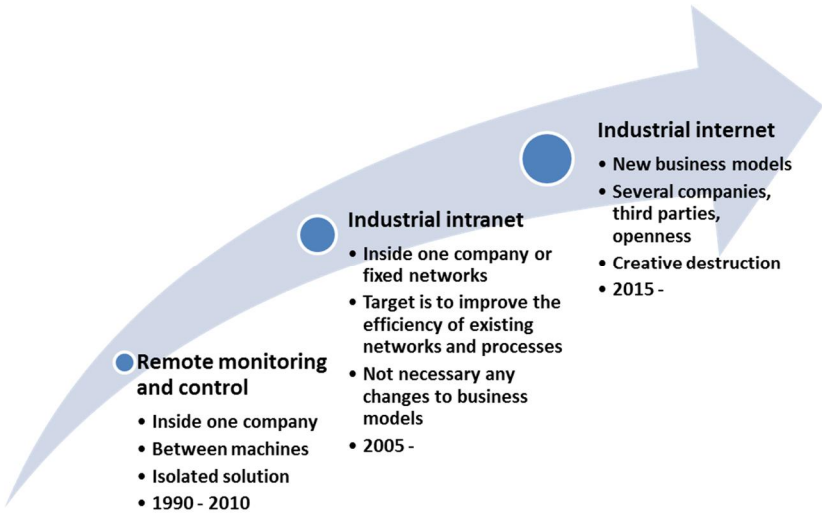

Figure 1. Development of Industrial Internet [Adapted from (Tihinen et al., 2016)]

In addition, the price of supporting technologies, such as sensors, data storage and processing capacity, has drastically lowered, enabling their adoption on a large scale.

European companies, as well as entire industries, are being challenged from two sides: first, newly industrialised countries are engaged in the competitive manufacturing industry, which has extremely low labour costs – and consequently, a significant number of manufacturing jobs have been lost; second, the companies sticking to traditional methods of operation are being challenged by their "fully digital" competitors. For example, traditional media companies – both print and TV – have already lost a major share of their advertisement revenue to search engine giants; likewise, traditional taxi businesses are facing a new kind of competition from Uber. While the consumer market has been leading the transformation, one should also expect a similar process to occur in the business-to-business market. Since the transformation is driven by digitalisation, Finnish IT houses have a central role in ensuring that their country's competitive edge both remains in place and, hopefully, becomes strengthened.

The TINTTI project is conducted as a joint endeavour with VTT, the University of Oulu, and is also associated with related industrial projects (IT houses). Therefore, it is a part of a larger consortium effort that collects a number of company projects (from IT houses) and one research project under the same umbrella. The goal of the TINTTI project is to support companies, particularly IT houses, in the development of new Industrial Internet-enabled IT services, solutions and

businesses. Finnish IT houses are ready and willing to take advantage of available business opportunities in the Industrial Internet field. In order to succeed in this area, they need to be equipped with new abilities and knowledge of the niceties of the discipline. With these assets, the firms can increase their customers' productivity and, in turn, their competitiveness.

2. Examples of Industrial Internet – Finnish case companies

This chapter introduces TINTTI case studies related to the application of the Industrial Internet in four Finnish IT houses: Absent Oy, IoLiving Oy, HiQ Finland Oy, and F-Secure Oyj.

2.1 Intelligent after-sales business – Absent Oy

Absent Oy is a Finnish SME software service provider located in Lapua, Finland. While the company is as yet small, it aims to be a notable player that provides sophisticated IT solutions and services for manufacturing companies in various domains. Currently, the company provides IT systems related to diverse post-manufacturing and after-sales operations, such as sales configurators, customer support systems and so on. Typically, Absent Oy's customers include equipment and machine manufacturers and industrial service providers.

2.1.1 Background – industrial services are booming

Absent Oy has recognised the business potential of the Industrial Internet. The prices of the components needed for these solutions (such as sensors) are getting increasingly lower. Awareness of both digitalisation and the Industrial Internet is spreading among industry leaders. Additionally, industrial services now form an important part of manufacturers' offerings. It has been observed that substantial revenue can be generated from an installed base of machines and equipment with a long lifecycle. The slow economic growth during recent years has boosted this development; new industrial service business and the rationalisation of related processes are being realised by industrial customers as things that they need to survive in international competition. Absent Oy understands that it is in a position to provide the relevant solutions and must act now.

2.1.2 Platform solution for data-based service business

As part of the TINTTI project, Absent Oy has designed a new concept solution called the Digital Service Support Platform (DSSP). This innovation provides a platform where the various stakeholders can connect. The solution can be used to create digital services for different stakeholders based on their individual needs, using existing and remotely monitored data. Below, Figure 2 shows the concept of DSSP.

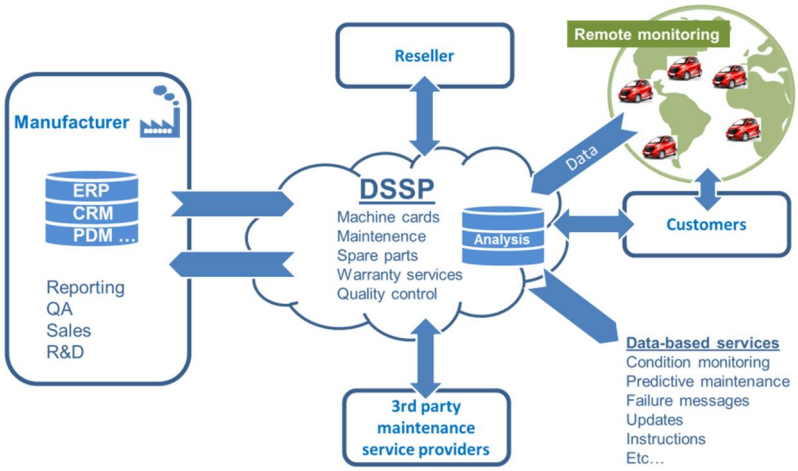

Figure 2. Digital Service Support Platform (DSSP)

Absent Oy decided to initiate the development of solutions that manufacturing companies can use to provide completely new data-based services to their customers, such as predictive maintenance. This would not be possible without the application of Industrial Internet technology for data collection, monitoring, transfer and analysis. The new technology brings cost-efficient solutions in these areas.

The company provides various kinds of aftersales IT systems that help manufacturing companies and their partners in, for example, maintenance, reselling, and warranty operations. The bottleneck in their offerings was the lack of a data monitoring and analysis solution that could be used to collect and analyse data from machines and equipment while they are in use in end users' premises.

The steps in DSSP development include the implementation, piloting and productisation of the solution. The company has built the solution. The company aims to pilot the solution in customer firms in different domains, to determine the extent of the benefits it can offer these organisations. Thereafter, the next step will be to fully launch the business and source international customers. This leads to the important question of how the solution should be presented to these overseas clients. It is necessary to construct rational sales arguments that can be deployed to convince such industrial partners of the benefits of the solution.

The company in question implemented a whole new solution, which can be integrated with their existing IT systems. A data collection bundle takes care of data collection, pre-analysis and transmission to the data analysis service. Said service analyses signals based on the rules that have been selected from the algorithm database (DB). A variety of services can be triggered in response to the data collected in the field. The data collection bundle, with analysis service, can also be used as stand-alone solution. However, integration with, for example, Absent's AfterSales IT system enables sophisticated lifecycle management and services for the entire fleet of equipment/machines. The data made visible to stakeholders –

such as manufacturer, third party service provider, reseller and so on – enable better participation for stakeholders in areas like manufacturing processes, products, maintenance, safety, warranty and quality-related issues.

2.1.3 Example scenario

Remote monitoring can be used to keep track of the status of machines in the field. Such items, including forest machines, cars and manufacturing equipment, produce a considerable amount of various kinds of data, such as temperatures, pressures, RPM and other sensor readouts. This data can be used to anticipate the need for industrial services, such as predictive maintenance. If the alarm limit is exceeded (or the value is less than the alarm limit), the DSSP system can send messages to selected destinations; for example, a maintenance notification request to the service company. The company can then view machine information directly from the DSSP system and, if necessary, download the required configuration details for the service work and select the correct spare parts for the service. Such cost-effective and speedy after-sales service is possible if up-to-date information on the individual machine is readily available.

More complex services can be enabled by the historical data that is collected from the entire fleet of machines. This includes information about the engine's temperature, operating angle and maximum load. When this historical data is combined in the DSSP system with data from the manufacturer's product developer or machine operator, we can create new services. For example, detailed information for the machine operator company about the individual machine (such as load, temperature and angle) can allow the company to identify risks, so that it may instruct its drivers on how to operate the machine correctly. The manufacturer may also identify recurring failures associated with a particular engine type and, based on that data, can look for the causes alongside the subcontractor (to assess why this is happening or to re-instruct the machine operators in terms of allowable operation load or angle, in order to avoid engine failures). In sum, the system allows a variety of services for different partners in the value chain, leading to a win-win situation for all concerned.

2.2 IoT service for food, construction and medicine industries – IoLiving Oy

IoLiving Oy is a small start-up founded in 2013, which currently employs seven people. The firm has created a reliable, low-cost and easy-to-implement service platform for the creation of Internet of Things (IoT) -related products and services. The platform features flexible data synchronisation, which operates reliably even in environments where there is no fixed internet gateway, such as when an end user device, such as a smart phone, is used as a gateway. This provides ample flexibility for products and business models. The company's mass production-ready reference implementation includes a low-cost, standalone, Bluetooth-based, IoT

hardware module that records, for instance, temperature, motion, humidity and carbon dioxide-level data, and provides control when integrated with other hardware.

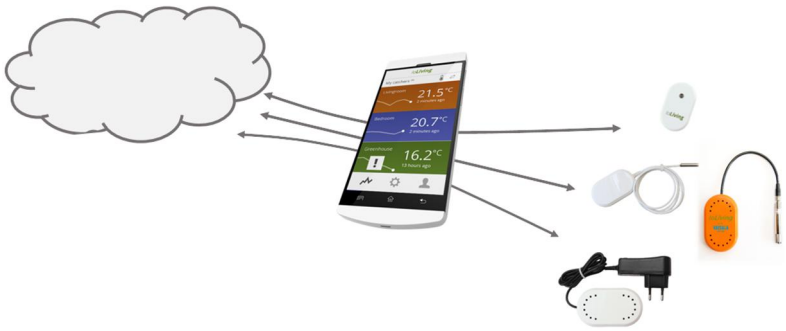

Figure 3. Example implementations of IoLiving's product

2.2.1 Automated food safety control at a restaurant in Kerava

“Maku” restaurant in Kerava, Finland, like any professional kitchen in Europe, monitors temperatures in its freezers, coolers, kettles and many other locations. Food safety regulations state that food temperature shall stay within the safe range. Previously, the restaurant would manually record temperatures by filling in paper forms, which were archived to folders. In September 2015, they adopted the IoLiving system, and temperature monitoring now takes place using a web browser. Small IoT devices collect temperature data continuously and use a smart phone to transfer the data to the cloud. In addition to automated temperature monitoring, the proprietors use a tablet computer to record the results of manual checks. Information is always available through any web browser, and automated alarms are sent to smart phones. As a result, productivity, food safety and food quality have improved.

Figure 4. Mobile user interface for collected data

2.2.2 Improved quality at a construction site

Builders at an Oulu city construction site used the IoLiving service to ensure that concrete was properly dried. The concrete slab has to be sufficiently dry before the surface is covered; otherwise, moisture damage will develop in the building while it is in use. The construction company, NCC, installed moisture sensors in five locations and followed the drying process and conditions using the web browser. This complemented the official manual moisture-measuring practices. Based on the feedback provided by NCC, continuous monitoring of concrete is useful, especially during the drying phase when air humidity and temperature are observed, as these factors have the largest influence on the speed of drying. In addition, monitoring the temperature of the concrete itself was necessary, as it enabled the completion of official check-in measurements. Using the service, it was possible to assess when it was reasonable to conduct another official check, thereby reducing the amount of unnecessary measurements. Continuous moisture monitoring adds value to the construction process.

Figure 5. Following the drying process and conditions using the web browser

2.2.3 A French boy's health problem prevented

A mother had been wondering why her son, who had diabetes type A, was not feeling well despite taking medication. She purchased a MedAngel product that used the IoLiving system; a small temperature sensor was placed in the fridge. After a few days of continuous monitoring, the mother received an alarm on her mobile phone advising that the temperature in the fridge had momentarily dropped to below freezing level. This was salient, as insulin loses its power immediately when frozen. The mother had relied on the manual freezer thermometer, which always displayed +3C when she observed it during daytime; however, during the night, he temperature plummeted. Continuous temperature monitoring also shows that the temperature inside a freezer does not remain even, and can vary by as much as 5C. This vital information prevented any further issues with the child's health condition.

Figure 6. Enabling personal health care at home

2.2.4 Productivity increased at a potato farm in Poland

The world's largest potato breeder, Solentum/HZPC, offered potato farmers an IoT solution for monitoring their growth, handling and storing processes. This is also based on the IoLiving service platform. A Polish potato farmer was aware that during the harvesting and grading of his crop, he inflicted more surface damage than did his colleagues in Holland. Using the IoT application, he measured the effects of his harvesting machine on the tubers and was able to pinpoint the phases in the process when the greatest damage was caused. The afflictions ruptured the skin of the potatoes and reduced the quality of the crop, as damaged tubers are more prone to infections. The farmer changed the settings of the machine accordingly and fine-tuned the process to the same level as seen in Holland. As the quality of the potato crop increased, this resulted in improved productivity and higher income.

Figure 7. Hidden information revealed through sensor data

2.2.5 Summary – IoT service is a new solution for existing needs

While restaurateurs, construction workers, mothers and farmers do not necessarily know that they need IoT, education on the platform should be offered as it can solve their problems more efficiently than conventional means. The phenomenon is the same as what has been seen with SMS, social media and messaging; the internet offers an inexpensive, easy-to-use and practical way to do things differently. Internet services can also be refined to meet new needs much more quickly than mobile apps. No native user interface (UI) is required to be developed; instead, any web browser anywhere can be used to access the IoT services.

2.3 Renewed service portfolio – HiQ Finland Oy

HiQ Finland Oy is part of HiQ International, a Nordic technology consultancy and service company. HiQ is listed on the Nasdaq Stockholm and has offices in the Nordic region and Russia. The firm helps its clients all the way from strategy, concept and design to technical development, implementation and operation. HiQ Finland is one of the oldest institutions within the Finnish ICT sector and consists of a highly experienced team of experts.

2.3.1 Background

The Industrial Internet of Things continues to influence all industries by creating new opportunities and challenging existing business models and value chains. HiQ is right in the heart of this development. With the technology becoming significantly

cheaper, smaller, more powerful and more connected, we can see that the user plays an increasingly important part in driving innovation. This creates entirely new opportunities and incentives for change. For HiQ, this means keeping up with the pace of change, having the right competencies and having a relevant service portfolio for customers.

HiQ has discussed this matter with many companies from different domains, and has observed that today, such firms see the Industrial Internet as an essential enabler through which they can grow and expand their service business. Accordingly, the companies are increasingly interested in the Industrial Internet and what it means for them. Many organisations lack the capabilities, resources and knowledge base to take advantage of various Industrial Internet opportunities or possibilities. Required changes will vary between companies, depending on their situation and targets. It is important that the firm has a clear strategic intent and committed employees who can drive the Industrial Internet to effect change. This is a long process, as the change is not purely technological but also entails alterations to processes and the organisational culture.

For HiQ, its focus on the TINTTI project was about identifying and defining possible business models, new services and requirements for new competencies in the area of the Industrial Internet. The concrete goal was to broaden the service portfolio, gain new customers and increase revenue by taking on Industrial Internet cases.

Figure 8. The Industrial Internet of Things depicted by HiQ

2.3.2 Focusing on service portfolio

One of the key objectives during the project was to identify competence areas on which HiQ needs to focus in order to proffer competitive service offerings. The

findings were that HiQ needs to strengthen its competence in digital business transformation, data analysis and service design expertise.

HiQ's Industrial Internet service portfolio was developed through the TINTTI project. A business innovation and transformation consultation service was created, and piloted with a select few customers. The service offering includes four packaged services, ranging from an Industrial Internet strategy consultation to implementation of a selected digital service prototype. Other services include support for alignment and prioritisation of a development roadmap based on an organisation's Industrial Internet strategy, and how to effectively utilise analytics capabilities to provide valuable insights that can support business objectives. New services were created, both for digital transformation consultation and for the analytics area.

However, it seems that in Finland, more focus is placed on optimising existing systems than on looking for new business models. Often, the Industrial Internet is seen as more of a technological change rather than a major business opportunity, but this is erroneous. The main outcomes of the TINTTI project were a highlighting of the importance of business objectives the creation of a transformation roadmap that can be deployed throughout the organisation and the construction of a service portfolio to support this change. During TINTTI, HiQ was able to renew and update its service offerings in selected business segments, in order to offer its' end customers their much-needed knowledge and competences.

2.4 Securing Industrial Internet environments – F-Secure Oyj

The F-Secure corporation, which has around 1,000 employees, is a cyber security and privacy company based in Helsinki. F-Secure has been protecting tens of millions of people around the world from digital threats for over 25 years. F-Secure has over 20 country offices and a presence in more than 100 countries, with Security Lab operations in Helsinki, Finland and Kuala Lumpur, Malaysia. Through more than 200 global operating partners, millions of broadband customers use F-Secure's services. The firm is the global leader in providing security as a service through operators, and also has OEM agreements with several security vendors to integrate detection technology engines with its own offerings. In addition, F-Secure has special product lines for home users, offering various security products.

2.4.1 Background

While F-Secure develops solutions both for consumer markets and business enterprises, its focus has until recently been on the former. Securing an IoT environment has been a vital element of F-Secure's strategic direction since 2015; one concrete indication of this was the corporate acquisition of nSense in June of that year.

In the area of industrial branches, the Industrial Internet-based technologies are rapidly changing the business logic of traditional branches one after the other, bringing advanced intelligence to functions on an unprecedented scale. When a

complex business environment becomes ever more dependent on digitalisation it also requires better protection. Due to this change, F-Secure is now developing solutions for industrial sectors and large companies, and expects to benefit from several business opportunities in this line of development.

Indeed, despite all of its benefits, digitalisation has increased the advanced targeted attacks that are performed by highly organised entities. The actors behind these attacks utilise highly sophisticated and advanced tactics, techniques and procedures to breach security infrastructures, and they maintain a persistent presence within an organisation. However, regarding advanced threats, awareness, demands, and environments differ significantly in different verticals, such as the finance and forest industries.

2.4.2 Changes in business and revenue logic

While traditionally, F-Secure has provided consumer market solutions, securing an Industrial Internet-type environment requires a transition to comprehensive enterprise solutions; this would establish F-Secure as a service provider that has long-term B2B relationships on a new scale and in greater depth. This requires special expertise of existing technologies and solutions, in addition to constant monitoring of the situation and changes to security environments worldwide.

Enterprise risk management has become a focus area, as security is no longer merely a technical issue. As data plays a vital role, it needs to be protected in a new way. Sharing data between partners, perhaps even in real time, opens up new possibilities for attacks. Ensuring a balance between vulnerability risks and new business opportunities is at the centre of this concern. Without data sharing, new business opportunities will remain unexploited, but sharing data without proper protection may lead to a catastrophe. The company will need to be prepared for how to continue its business after a possible network intrusion, and new ways of thinking are needed.

In the TINTTI project, F-Secure increased its competence in the new business and technology domain. One important aspect of this was to understand the perceptions in different markets and countries. F-Secure conducted 19 interviews in three countries: the United States (US), Germany and Finland. The US represented the most mature market and Germany represented the target market. Finland offered a benchmark for the other two markets. The research results shed light on the current situation and challenges in different verticals.

2.4.3 Protecting the Industrial Internet business environment

Protecting an Industrial Internet-based business environment requires conceptualisation of security and management of a services portfolio. This includes the overall view, security analysis, measures for securing digital business, detection of attacks and threat intelligence – that is, understanding the material that attackers are interested in. Additionally, the 24/7 telecommunications network monitoring

service, including collection of information and analysis of data, is a natural part of network protection as it enables recovery and minimisation of damages. The importance of rapid detection of attacks has become more pronounced.

The TINTTI research results were primarily exploited for incubating a Rapid Detection Service. The illustration presented in Figure 9 depicts how the Rapid Detection Service works. It shows how F-Secure has developed a new type of service offering and a new level of service competence. Scaling and accelerating this new type of service and helping different verticals understand the critical nature of security as a component in the age of digital transformation are future challenges that must be addressed and tackled.

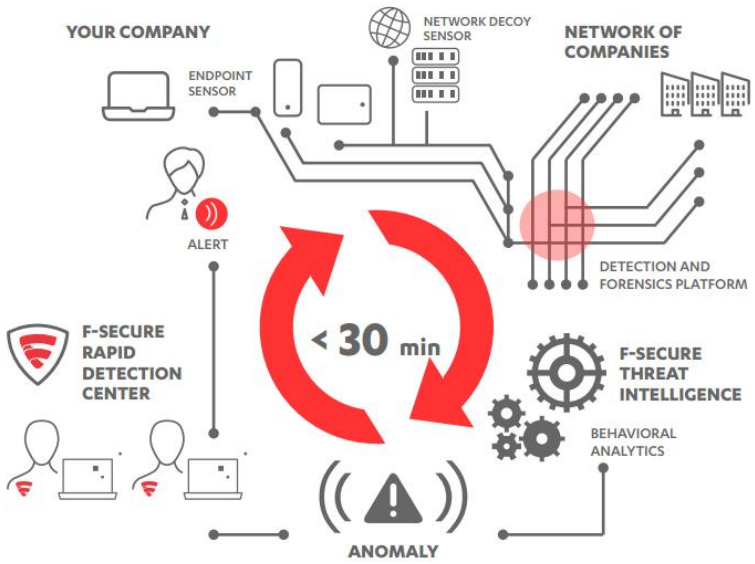

Figure 9. An illustration of how the Rapid Detection Service works in practice.

3. Snapshots of Industrial Internet practices in Finland

For this work, two surveys were carried out to enhance our understanding of the progress and practices related to IoT and the Industrial Internet in Finland. The first one was mainly concerned with IoT and associated topics, while the second was focused on the Industrial Internet practices, experiences and expectations of Finnish companies. Both surveys were implemented using a web-based tool.

3.1 IoT questionnaire

The IoT questionnaire was sent to all participants in the Industrial Internet seminar (19th November 2015) in Oulu, Finland, and to all persons who took part in the resultant seminar on the IoT programme (3rd December 2015) in Espoo, Finland.

3.1.1 Background information

The questionnaire was sent to 241 people, of whom 57 responded. A map of the business scope of all respondents is shown in Figure 10.

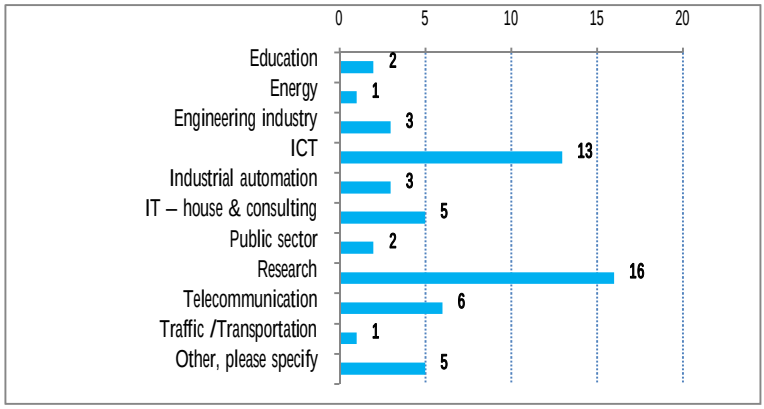

Figure 10. Business scope of the IoT questionnaire (N = 57)

Most of the respondents represented companies (36 out of 57), while the remaining 21 were from the public sector (including education, research and media).

The majority of respondents represented large companies with over 500 employees, although some were from smaller ones with staff numbering less than 30. Most of the public sector organisations were research bodies with over 500 employees.

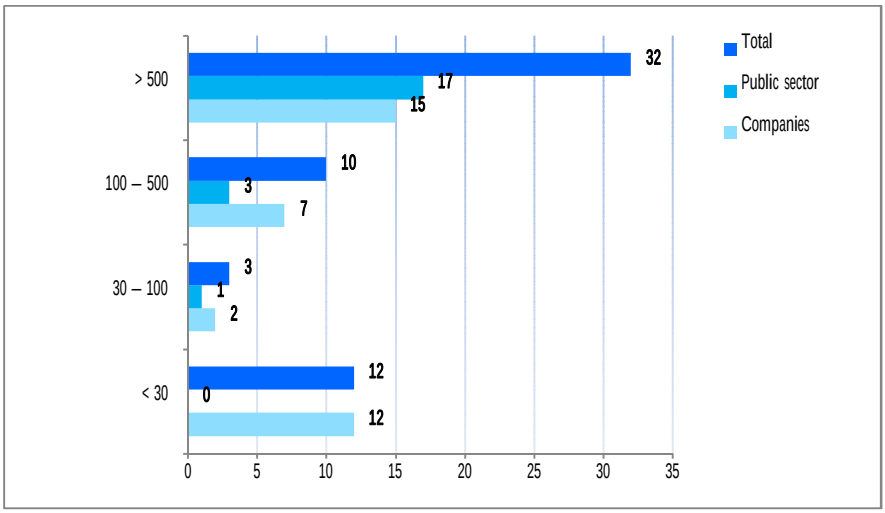

Figure 11. Number of employees (N = 57; 36 companies, 21 public sector)

Most of the respondents indicated that their organisation had already exploited IoT technologies in their business, illustrated in Figure 12.

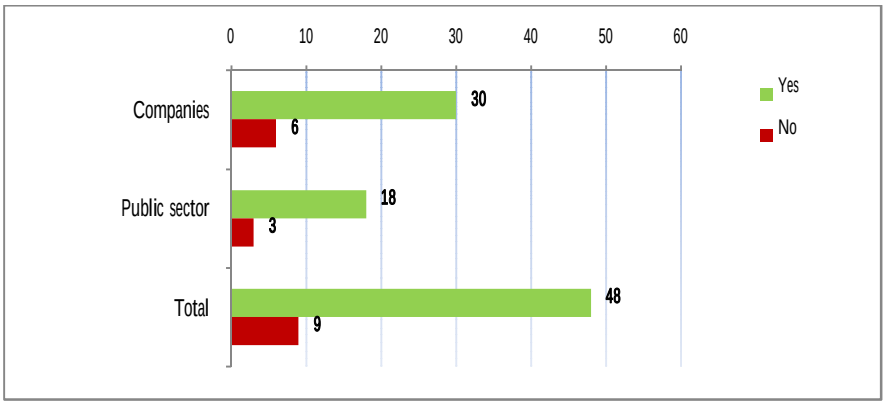

Figure 12. Have organisations exploited IoT technologies in their business? (N = 57; 36 companies, 21 public sector)

The first concrete steps that the bodies had taken in implementing IoT solutions related, for instance, to IoT packages for customers and platform solutions. In addition, some respondents intimated that they were evaluating potential use cases or researching and developing proofs of concept, pilots or prototypes related to the IoT. The respondents also stated what kind of customer needs they had identified related to the IoT. While these answers varied widely, more than a quarter related to data monitoring and utilisation.

About 80% of company representatives indicated that IoT was a vital part of their company's strategy, whereas this figure was about 60% in the public sector responses.

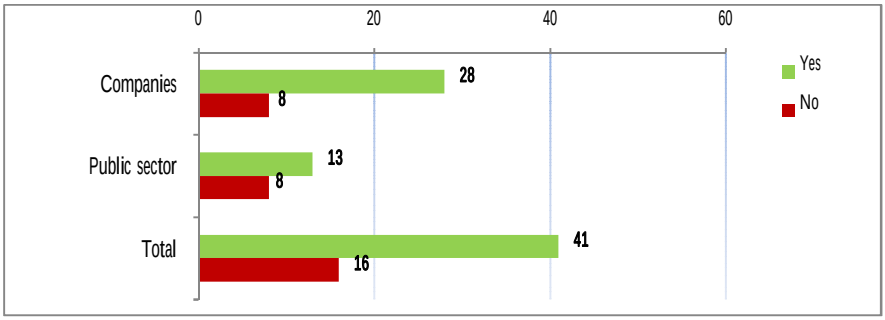

Figure 13. Is IoT a vital part of your strategy?
(N = 57; 36 companies, 21 public sector)

The IoT questionnaire also asked whether a roadmap for IoT-based products and/or services had been created by the respondents' companies. In total, 70% answered in the affirmative. When filtering the data by company and public sector responses, the result was divergent. About 80% of company representatives indicated that they had created a roadmap, whereas this figure was about 50% in the public sector responses.

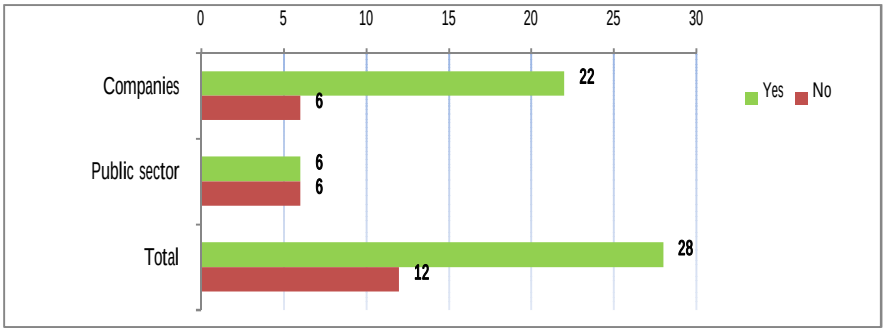

Figure 14. Have you developed a roadmap for IoT-based products and/or services? (N = 40; 28 companies, 12 public sector)

3.1.2 Benefits

The top three benefits the respondents had noticed, or would expect to achieve, through the exploitation of IoT were: *new business opportunities*, *better customer satisfaction* and *cost savings*. *New business opportunities* was the top benefit in

both respondent groups (companies and public sector bodies). The results have been illustrated in Figure 15.

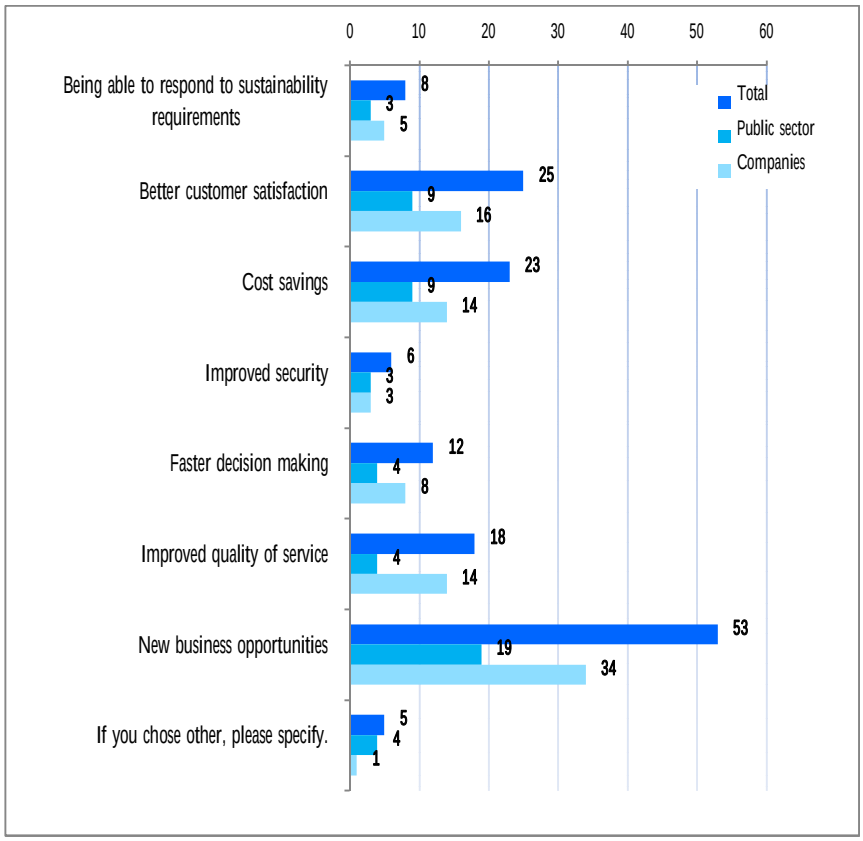

Figure 15. Benefits that have been noticed or expected when exploiting IoT. (N = 57; 36 companies, 21 public sector)

Other non-predefined benefits that were identified by the respondents were, for example, *education of students*, *ability to exploit many kinds of data sources end-to-end, improved trust (that everything is OK)* and *faster ramp-up*.

When selecting responses where the company size was either >500 employees or <30 employees, the results were somewhat similar (Figure 16).

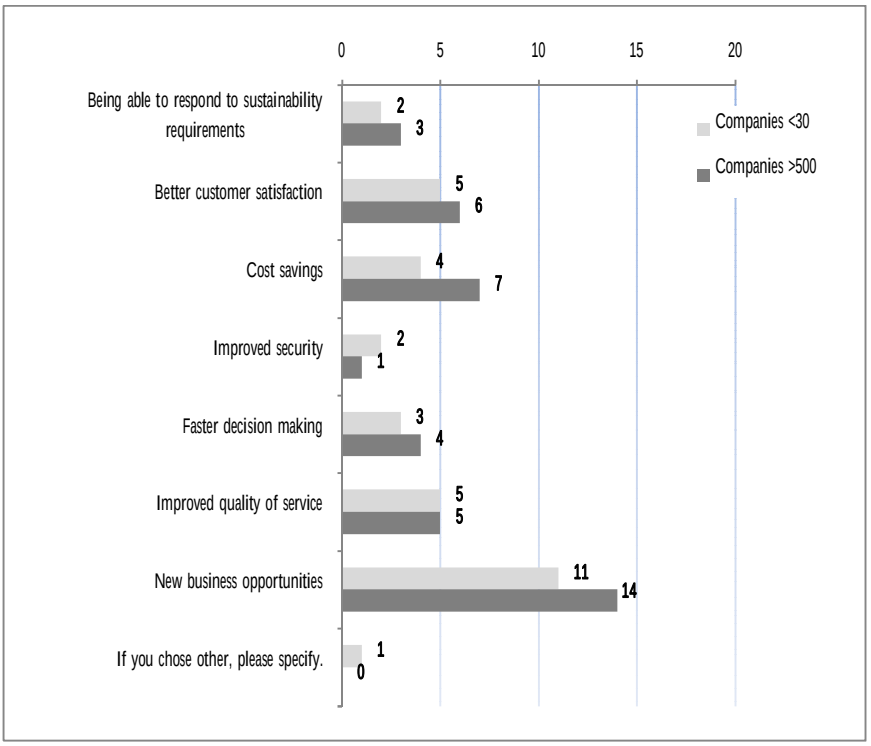

Figure 16. Benefits that have been noticed or expected when exploiting IoT. (N = 27; 12 companies <30 and 15 companies >500)

The main benefits that were expected to achieve were explicitly *new business opportunities* through the exploitation of IoT.

3.1.3 Challenges

Challenges were studied according to the following categories: *company-related* challenges, *business development*-related challenges and *technological* challenges.

Company-related challenges:

The top three company-related challenges were: *Lacking IoT strategy*, *Low awareness of the strategic importance and impact of IoT* and *Lacking competences and skills,* shown in Figure 17. This was the same for both the companies and public sector response groups.

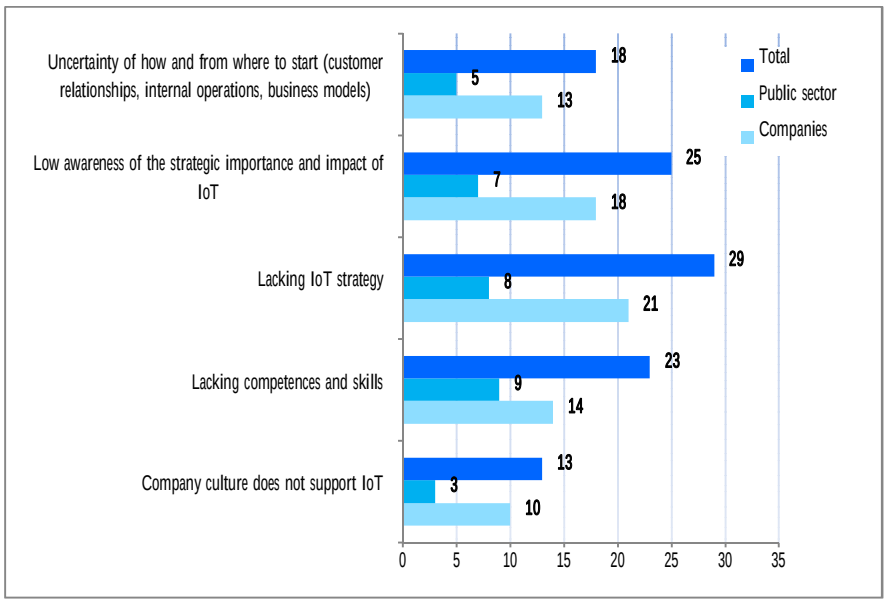

Figure 17. Company-related challenges by domains.
(N = 51; 34 companies, 17 public sector bodies)

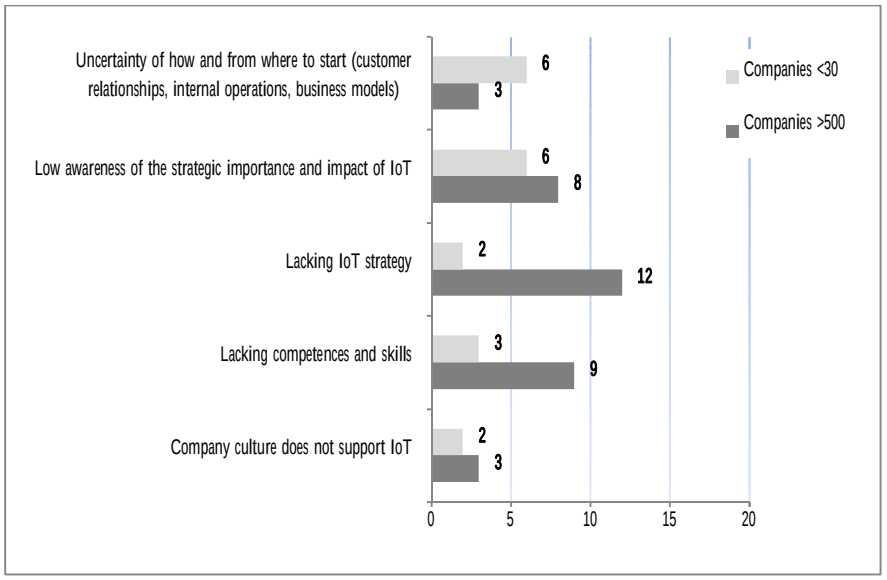

Figure 18. Company-related challenges by organisation size.
(N = 25; 15 companies of >500 and 10 companies of <30)

In the response groups “companies of >500 employees” and “companies of <30 employees”, the results were slightly different. In the former, the top three challenges were *Lacking IoT strategy*, *Lacking competences and skills* and *Low awareness of the strategic importance and impact of IoT*. In the latter, meanwhile, they were *Uncertainty of how and from where to start (customer relationships, internal operations, business models)*, *Low awareness of the strategic importance and impact of IoT* and *Lacking competences and skills*.

Business development-related challenges:

The top business development-related challenges were: *Business model creation*, *Commercialisation*, *Immature markets, Finding suitable partners* and *ROI is unclear or difficult to calculate*. Most of the respondents identified *Business model creation* as the biggest challenge, regardless of group.

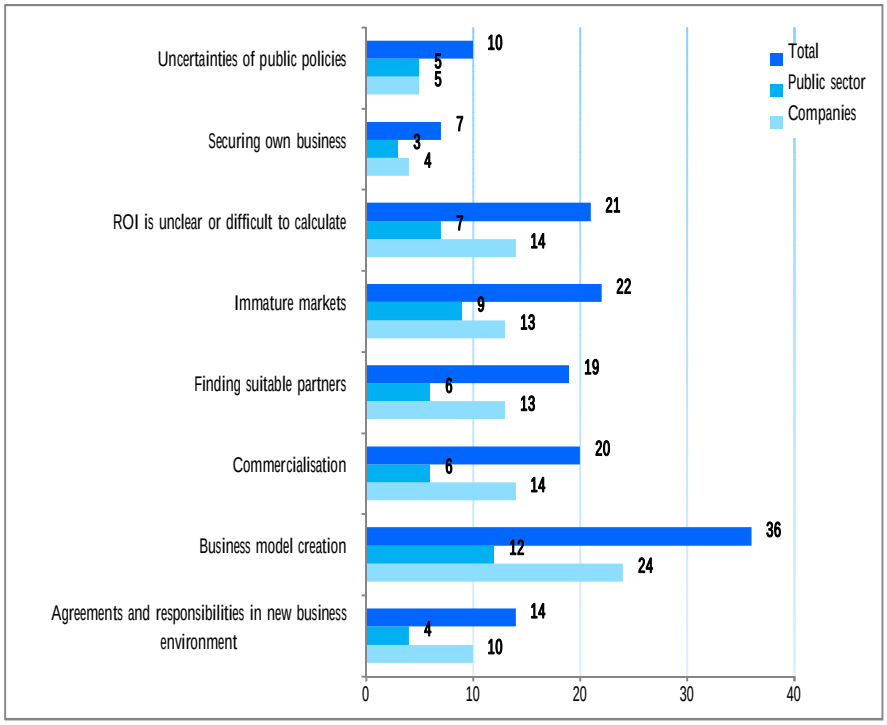

Figure 19. Business development-related challenges by domains.
(N = 54; 35 companies, 19 public sector institutions)

When filtering data based on organisation size of either ”companies of >500 employees” and “companies of <30 employees”, it was seen that the challenge of *Business model creation* was the most identified in both groups (Figure 20).

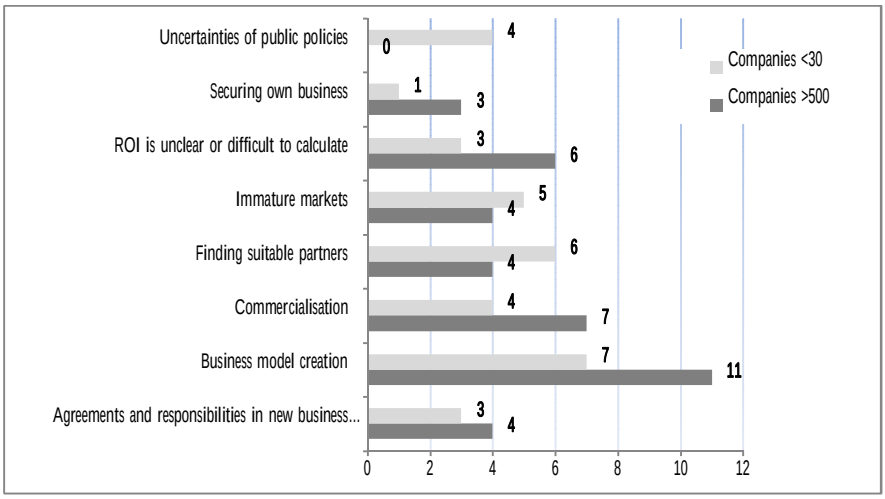

Figure 20. Business development-related challenges by organisation size.
(N = 26; 15 companies of >500 and 11 companies of <30).

Technological challenges:

The top technological challenges were: *data security, missing or competing standards* and *multiplicity and incompatibility of technological platforms,* as illustrated in the Figure 21.

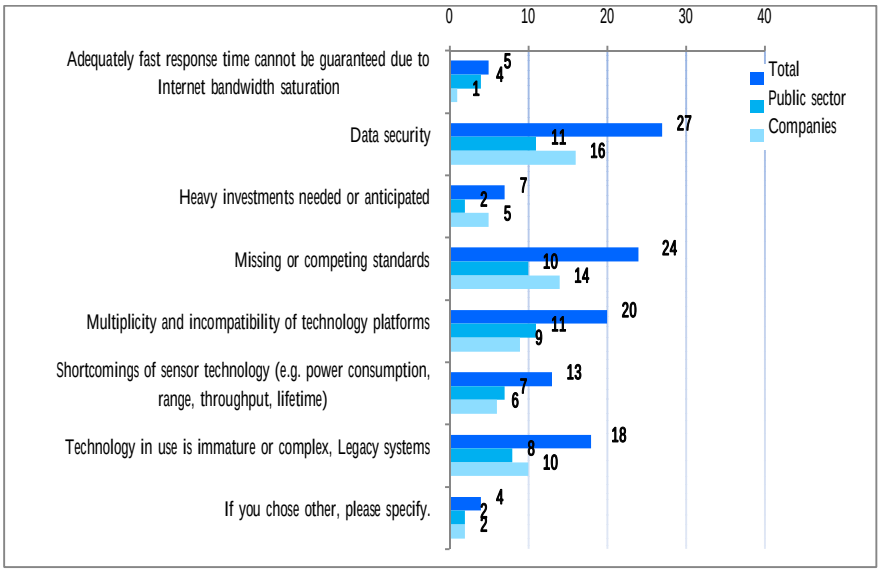

Figure 21. Technological challenges by domains.
(N = 53; 33 companies, 20 public sector bodies)

When filtering data based on organisation size, the top technology challenges identified by small companies were seen to be slightly different, as follows: *missing or competing standards, data security, shortcomings of sensor technology* and *technology in use is immature or complex* (Figure 22).

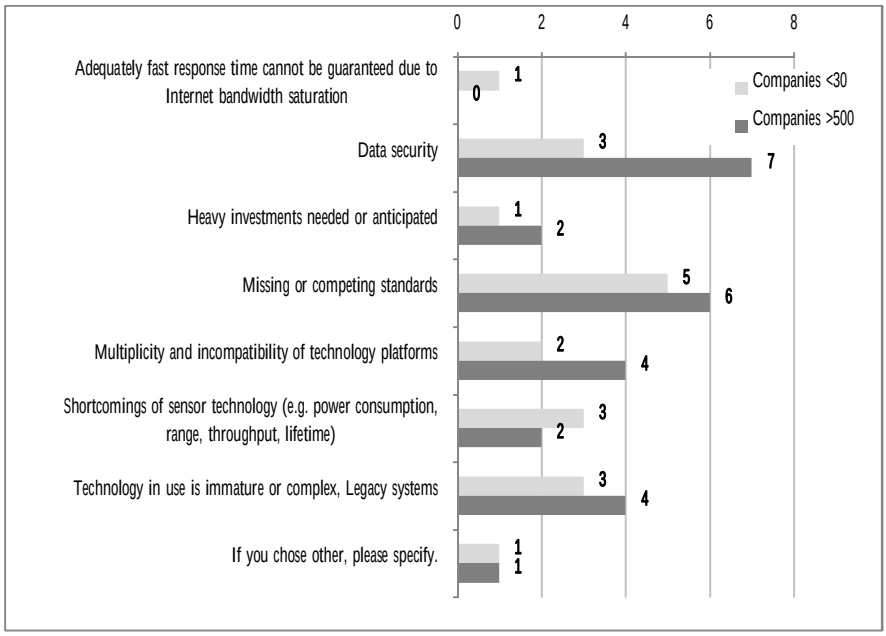

Figure 22. Technological challenges by organisation size.
(N = 23; 13 companies of >500 employees and 10 of <30 employees)

The results showed that most of the respondents identified Data security as the greatest challenge, regardless of group.

3.2 Industrial Internet barometer 2016

The Industrial Internet barometer was processed during the spring and summer of 2016. The questionnaire link was sent via email to the same set of respondents as for the IoT questionnaire. The link was also sent to all potential contacts of the TINTTI project members. In addition, it was available on the webpages of Tivi and Tekes, and link was freely forwarded via email in an attempt to maximise the number of responses. To foster a consistent understanding of the terminology and topic, the barometer included the following description: "*Industrial Internet connects intelligent machines, equipment, users and organisations together so that decision making can be improved by using advanced data-analytics methods. Therefore, the Industrial Internet automates and rationalises operations, increases efficiency and enables new business in the new ecosystem. In this questionnaire, Industrial*

Internet-related technologies and possibilities are intended to do the following: for example, utilisation of big data (gathered via smart sensors) in companies' current or new businesses; utilisation of new network opportunities in developing new services/products; utilisation of digitalisation (such as in technologies or applications) in expanding services/products or intensifying companies' own operations".

3.2.1 Background information

As mentioned above, the Industrial Internet barometer was freely available on the web, and the link was sent to an unknown amount of recipients while it was open (11th May.– 19th June 2016). In all, a total of 58 people answered the barometer.

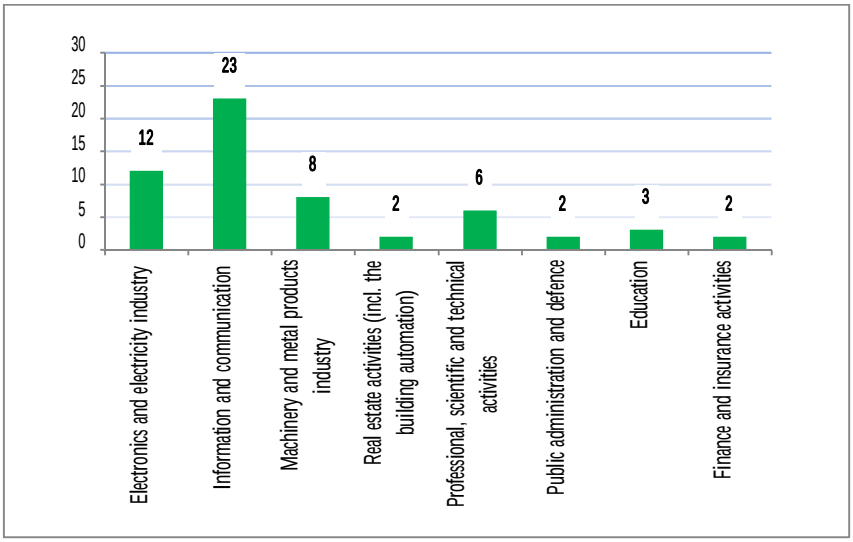

Figure 23. Business scope of the Industrial Internet barometer (N = 58)

The majority of respondents represented information and communication companies (23 out of 58). In addition, electronics and electricity companies (12 out of 58) and machinery and metal products firms (8 out of 58) were accounted for.

The organisations' sizes varied greatly among respondents; a large proportion represented either very small or very large institutions, as illustrated in Figure 24.

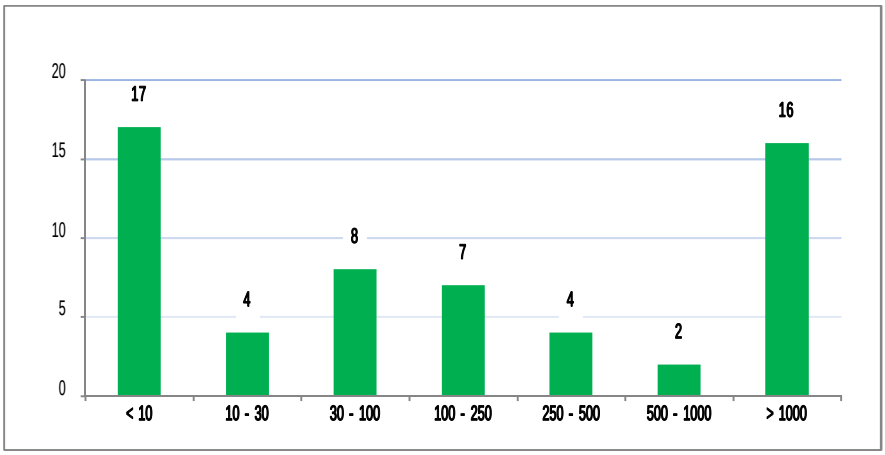

Figure 24. Number of employees (N = 58)

According to the barometer, 62% of respondents (N = 36) stated that Industrial Internet technologies or possibilities had already been exploited in their company's business.

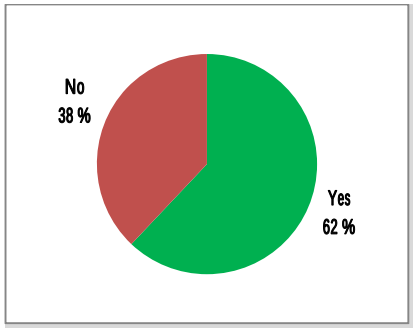

Figure 25. Breakdown of Industrial Internet exploitation (N = 58)

An interesting result arose from the question in which the participants were asked to give their best estimation of the year when Industrial Internet technologies or possibilities were first mentioned in their company's strategy: Figure 26 shows that the momentum is ongoing. In fact, over half of respondents informed that the Industrial Internet had been included in their company's strategy by 2014, and this growth was increasing (N=31 because 5 of 36 respondents were excluded as they could not give any estimation).

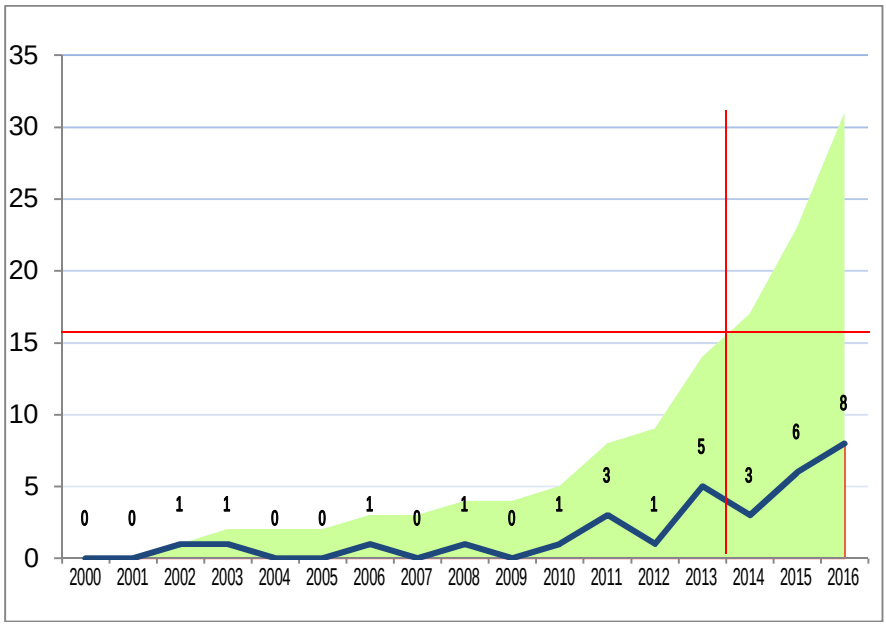

Figure 26. The first year when Industrial Internet was included in companies' strategies. (N = 31)

3.2.2 Main reasons for exploiting

The Industrial Internet barometer yielded the main reasons for companies exploiting, or not, Industrial Internet-related technologies. In total, 22 of 58 respondents stated that the various possibilities had not yet been explored by their company. The main reasons were identified as being uncertainty as well as lack of knowledge of the potential.

The top three reasons for *not exploiting* were:

1. Industrial Internet possibilities and alternatives had not been sufficiently studied (15)
2. Industrial Internet possibilities were not known (13), and
3. Industrial Internet technologies were considered unsuitable for the company's current business (7).

Figure 27 shows the overall spread of identified reasons for *not exploiting* the Industrial Internet's possibilities.

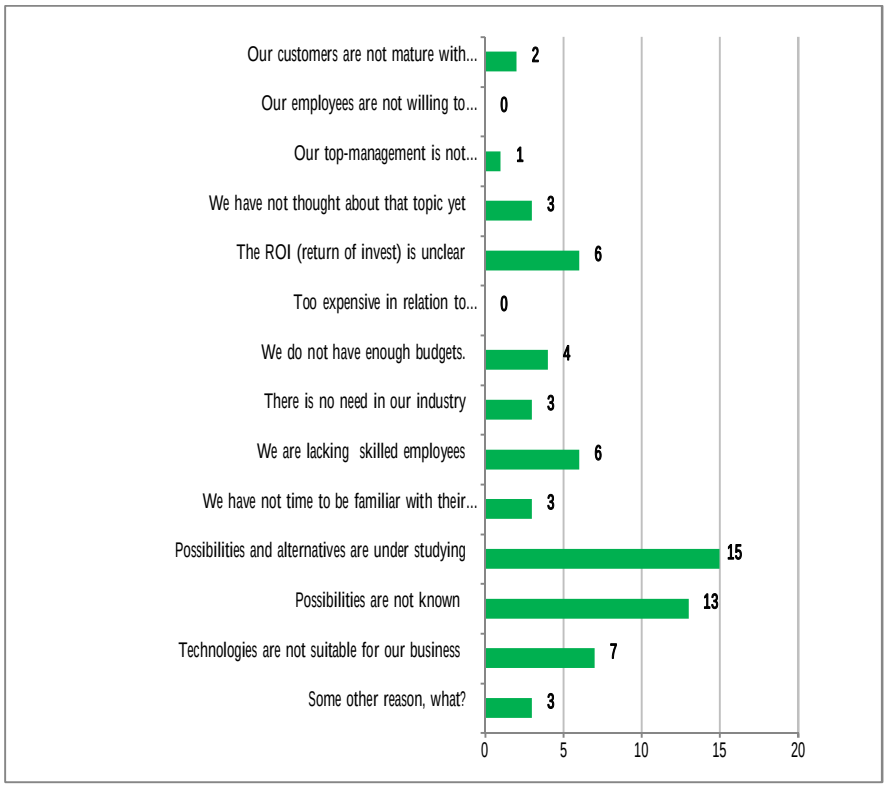

Figure 27. The main reasons for not exploiting the Industrial Internet's technologies or possibilities. (N = 22)

In addition, the barometer requested respondents' estimation of their company's best potential timeframe for beginning to exploit the Industrial Internet's possibilities.

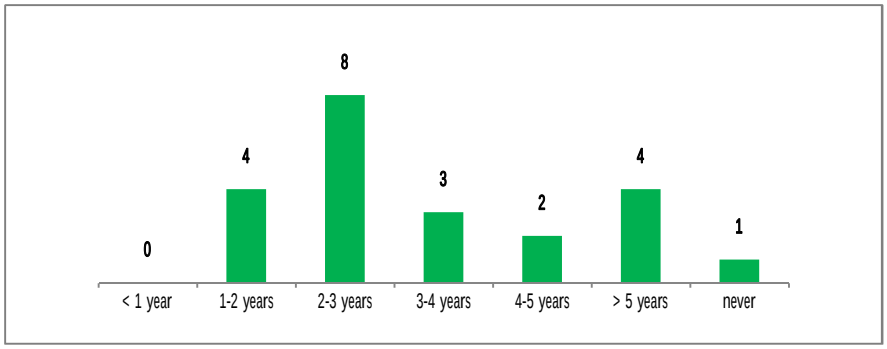

Figure 28. Timeframe for starting to exploit (N=22; not exploited yet)

The results showed that half of participants estimated that the process would begin within the next three years, as illustrated in Figure 28.

Correspondingly, the Industrial Internet barometer also inquired about the main reasons for *having already started to exploit* Industrial Internet-related technologies; the spread of responses is shown in Figure 29.

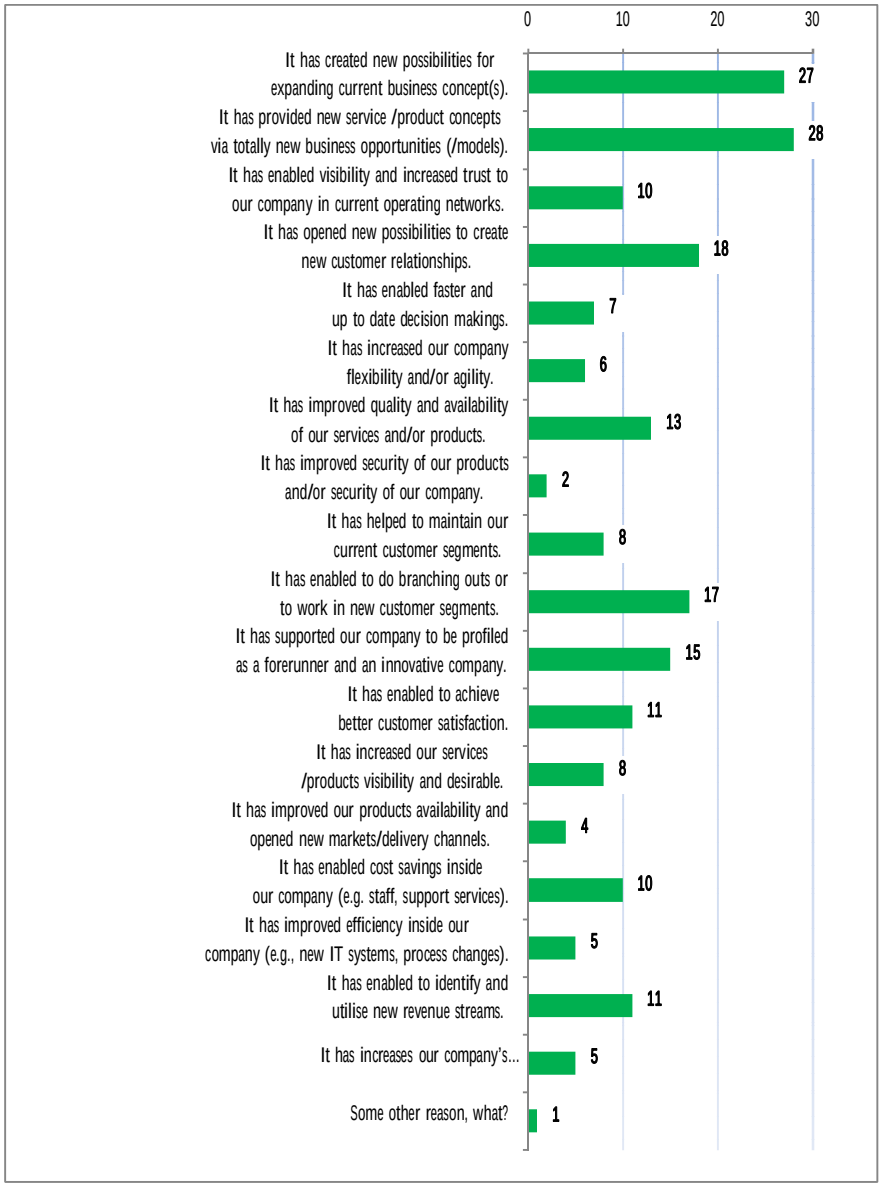

Figure 29. The most important reasons for exploitation. (N = 36)

The main reasons for exploitation centred around the "value proposition" element of the well-known Business Model Canvas, as follows:

- Industrial Internet possibilities had provided new service or product concepts via totally new business opportunities (/models) (28), and
- Industrial Internet possibilities had created new possibilities for expanding current business concept(s). (27)

In addition to the value proposition, the reason "*It has opened new possibilities to create new customer relationships*" was highlighted as being the third most important (18), while the fourth most important was focused on customers: "*It has enabled us to branch out or to work in new customer segments*" (17).

3.2.3 Insights into the near future

The Industrial Internet barometer also measured what activities would be performed by companies in the near future. The results were analysed by grouping data into "Yes" and "No" groups, depending on whether or not Industrial Internet-related technologies had been exploited by the respondents' companies. In those companies that had not exploited Industrial Internet technologies or possibilities, the main identified reasons were lack of information and knowledge. Accordingly, the activities they may potentially perform in the near future were (shown in Figure 30):

- They will increase awareness of the strategic importance and impact of digital transformation and the Industrial Internet. (11)
- They will identify potential business partners and networking. (11)

Correspondingly, in those companies where Industrial Internet possibilities were already being investigated, the following activities were identified to be performed in the near future (shown in Figure 30):

- They will identify and plan new commercialisation service(s). (24)
- They will provide a vision and a roadmap that includes the Industrial Internet. (23)

The results show that firms have realised that digital transformation does not happen by itself; instead, a systematic and proactive approach is needed.

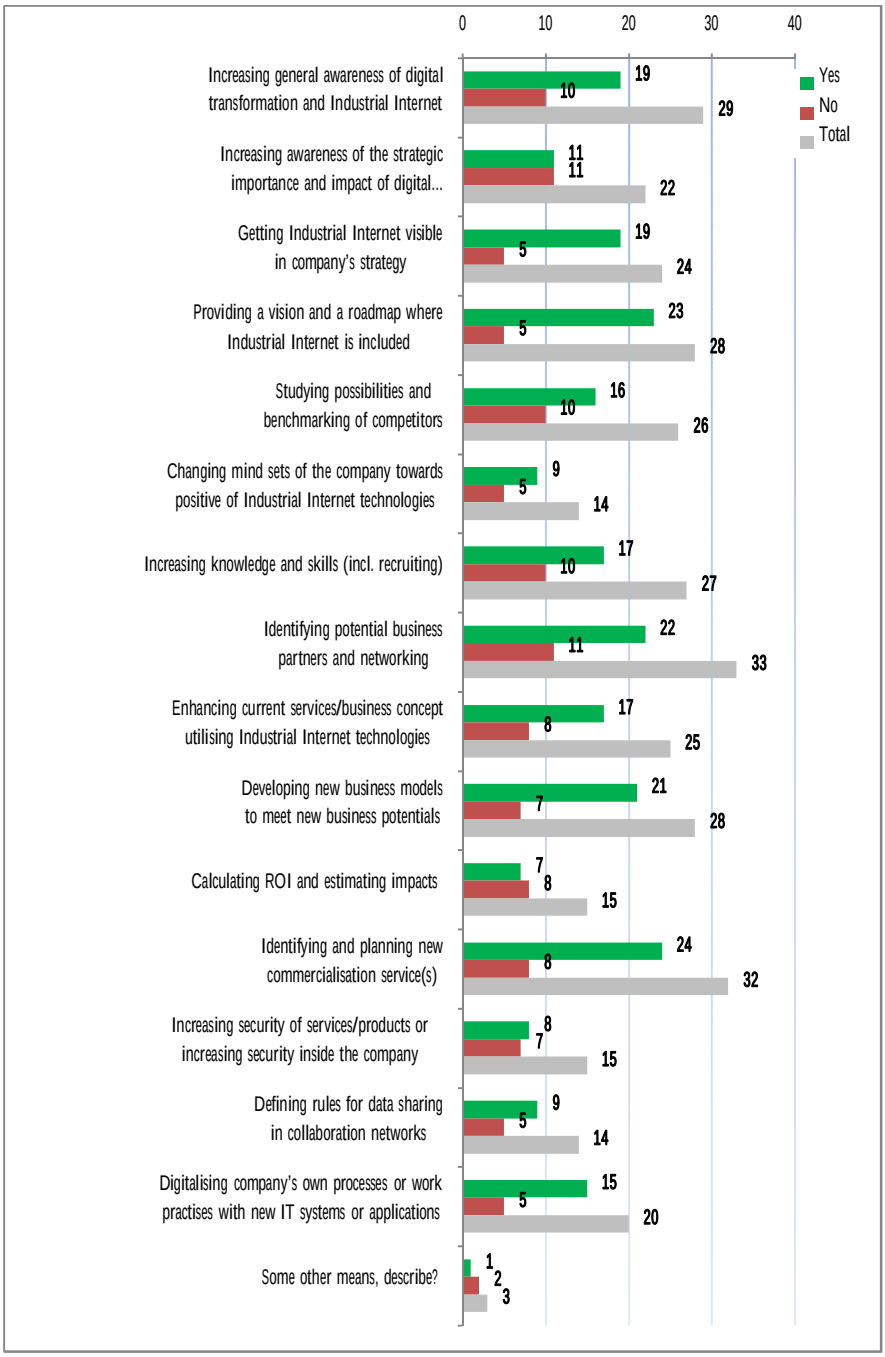

Figure 30. Activities to be performed in the near future (Yes, N = 36; No, N = 22)

3.3 Summarisation of surveys

Two different surveys were carried out during the TINTTI project; these were organised to increase understanding of the progress and practices relating to IoT and the Industrial Internet in Finland. However, the surveys had their own specific focus and goals as regards the TINTTI project.

The first one, the IoT questionnaire, was focused on identifying the main IoT-related challenges and expected benefits in Finnish companies. It also endeavoured to obtain a picture of the IoT progress and to identify research topics and areas covered by the TINTTI project. The second survey, the Industrial Internet barometer, was focused on Industrial Internet practices, experiences and, especially, expectations within Finnish companies. The survey was used as a barometer in general; to measure the Industrial Internet atmosphere in Finnish companies, as well as to forecast Industrial Internet-related activities in the near future in Finland.

In the first questionnaire, most of the organisations indicated that they had already exploited IoT technologies in their business and that it was a vital part of their strategy. In addition, such companies had developed a roadmap for IoT-based products or services.

Digitalisation impugns the existing ways of working, opening up possibilities for cost efficiency and quality improvements. It also leads to entirely new business avenues. These are arguments that are often used when justifying digitalisation. Similarly, in our surveys, almost all respondents to the IoT questionnaire saw "*New business opportunities*" as a main benefit that they had perceived, or would expect to achieve by exploiting IoT. They further labelled "*better customer satisfaction*" and "*cost savings*" as perceived or expected benefits.

The survey showed that organisations require a higher level of understanding and competences/skills related to the IoT. In particular, smaller companies indicated that they need more understanding of "*how and where to start related to IoT*" and a better grasp of the "*strategic importance and impact of IoT*". To support this, the TINTTI project has started to develop a digital transformation model that provides systematic steps for companies in their digitalisation work (see Chapter 5 for more information about the digital transformation model).

An interesting result of the survey was that most of the companies indicated that IoT was an important part of their strategy, but that "*Lacking an IoT strategy*" was indicated as a top challenge in the respondent group of companies with more than 500 employees. This may indicate that while IoT is within their sights, many of them do not have a strategy devoted to it. From the business development-related challenges' point of view, the most challenging aspect is the "*business model creation*". This is a natural step, since digitalisation could enable a whole new business that may differ considerably from the original one, such as moving from a product-based business to a service-based approach.

The Industrial Internet barometer focused on the Industrial Internet practices, experiences and expectations of Finnish companies. One of the main topics was to clarify the types of activities that would be performed by companies in the near future. In addition, one idea is to repeat the barometer annually or every other year

in order to gather data and acquire knowledge about the trends and topics that should be researched. This kind of approach helps create new supportive actions to address the needs of companies. It makes it possible to disseminate the impact and experiences to all companies in Finland, and around the world.

The barometer showed that II technologies/possibilities had already been exploited in most of the company's business. Respondents were asked: When were II technologies or possibilities first mentioned in your company's strategy? Their responses indicate that the momentum is ongoing. Furthermore, the main reasons for not exploiting II technologies were related to the company's concern about the lack of information and knowledge. This result was congruent with results obtained from the Internet of Things (IoT) questionnaire. Moreover, the main reasons for exploiting II technologies/possibilities were very similar to the benefits that were identified in the IoT questionnaire. However, in the II barometer, the examples given for the main reasons were categorised according to the nine main elements of the widely-known Business Model Canvas (value proposition, key partners, key activities, key resources, customer segments, customer relationships, customer channels, cost structure and revenue stream). This was done to clarify the force drivers that are used to exploit II technologies. The barometer indicated that the main reasons for exploitation centred on the "value proposition" element including "providing totally new business opportunities (/models)" and "creating new possibilities for expanding current business concept". In relation to customers, the respondents highlighted the following reasons for exploiting II technologies: "opening new possibilities to create new customer relationships" and "enabling us to branch out or to work in new customer segments". Cost saving reasons weren't emphasised as drivers for exploitation.

Furthermore, when analysing the next steps or activities that enterprises would potentially perform in the near future, the results were unambiguous. In those enterprises that were not yet exploited, the possibility of II technologies increasing a company's awareness of the strategic importance and impact of digital transformation, as well as identifying potential business partners and networking in the near future, were emphasised. Accordingly, in the enterprises that were already exploiting II technologies, the activities focused on identifying and planning new commercialisation service(s) and providing a vision and a roadmap where II is included. It was understood that digital transformation does not happen by itself; it requires decisions by management and a systematic way to proceed.

When identifying the estimated timeframe for upcoming activities, the result was unambiguous: the possibilities for II technologies will be increasingly exploited in the near future, as shown in Figure 31.

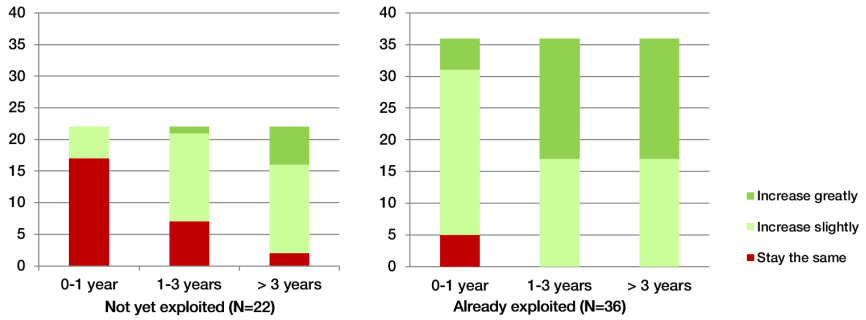

Figure 31. Industrial Internet investments in the near future
(N=22, Not yet exploited; N=36, Already exploited)

The graphs in Figure 31 illustrate how the exploitation of II technologies and possibilities are estimated to increase in the near future (Stay the same, Increase slightly, Increase greatly), both in the "Not yet exploited" group and in the "Already exploited" group. What is remarkable is that not a single respondent estimated that the exploitation would be decreased; indeed, the rate only increased. Companies are ready for these changes and they actively try to identify the potential for II to be utilised in their business operations, even if many uncertain and unknown issues remain to be tackled.

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4. Industrial Internet-based business

This chapter summarises the Industrial Internet as a business environment, where business potential, expectations, models and vital elements of transformation are reflected in interviews, workshops and meetings during the TINTTI project, as well as in the available literature.

The ubiquitous presence of the Internet is a fact. Despite this, while many buildings already have sensors in an attempt to save energy; home automation is occurring; cars and traffic lights have devices for improving safety and transportation; people have smartphones with sensors for running many useful applications; and healthcare services are relying on increased home sensors to support remote medicine, health maintenance and so on, such developments are merely the tip of the iceberg. Stankovic (2014) pointed out that all of these initiatives are still in the early stages of development, meaning that in the future people will have qualitatively different lifestyles from what is common today. However, we cannot predict how our lives will change. For example, the rise of social media and networks such as Facebook and Twitter, or the millions of apps that are available for smartphones, was not predicted by anyone; and these have all fundamentally changed our society and lifestyles. Therefore, businesses naturally feel some uncertainty when moving towards further digitalisation and opportunities surrounding the Industrial Internet. In the TINTTI project, these uncertainties were identified as belonging to two parties; the case companies (IT houses) themselves, and their potential partners and/or customers. Three main uncertainties affecting the realisation of Industrial Internet-based business opportunities, expectations and challenges were observed to be: an understanding of the business potential of the Industrial Internet as a whole, the new and alternative business models required and the new kinds of organisational roles and choices needed.

4.1 Business expectations and challenges

In this sub-section, studies relating to challenges and opportunities from the viewpoint of Industrial Internet-based business expectations are discussed. In addition, the business forecasts of well-known bodies are briefly recapitulated.

4.1.1 Business revolution

IoT has been termed a quiet revolution, with good reason (Economist, 2013). This statement has come about due to consumers and end users only noticing IoT in the form of new or improved services that are available to them. As an example, an individual who has a smart meter in their home does not think of their house as being a part of the IoT-enabled business environment. However, when we expand the viewpoint from consumers' experiences to the Industrial Internet-based business creation environment, the revolution is by no means either quiet or invisible for the business stakeholders concerned. The Industrial Internet is altering the

service or product provider's position from how we traditionally used to understand it, requiring new types of networked co-operation; earlier competitors may even need to become partners (Economist, 2013). To fully exploit the business opportunities offered by current IoT technologies calls for radical changes in methods of doing business. This may require new earning logics among partners. This all-encompassing shift in operation modes is undoubtedly a significant challenge for any company (Economist, 2013; IDC InfoDoc, 2014; Industry of Things World, 2015).

The formerly clear relationships between customers and service providers are also becoming increasingly blurred. Tightly networked business operations for value creation require seamless co-operation among various service and technology providers. This setting naturally leads to the question of who "owns" the customer, and what does the customer want from this relationship? Gartner (LeHong and Velosa, 2014) put forward an example from the context of a connected home. If a customer has a thermostat with an internet connection, whom will she conceive to be her service provider: the thermostat company, the utility company or the telecom service provider? There is no definite answer to this question, although the business environment, the competitive positions of involved partners and the agreed earning logics may determine the winner.

4.1.1 Economic growth expectations

The influence of the IoT or Industrial Internet-enabled business on the economy is expected to be huge, according to all well-known and respected forecast bodies and private stakeholders when setting out their optimistic business forecasts. In the following sub-section, we recap some of the latest examples of business potential predictions.

According to Frost and Sullivan (2015), the IoT market is expected to exceed 50 billion installed units by 2020. By comparison, the market for smartphones, tablets and PCs will be far smaller, at 8.3 billion. This is likely to significantly affect supply chain operation models. Additionally, it is assessed that 82% of organisations who have implemented a smart manufacturing process will experience increased efficiency in their product development activities and a 30% increase in production by implementing IoT technologies in their production line (Frost and Sullivan, 2015). In general, manufacturing industries are expected to benefit from vast new revenue opportunities by using IoT technologies. In the US alone, it is expected that the discrete manufacturing industries will see an increase of US$746 billion in revenue by 2018 (IDC InfoDoc, 2014). In the Industrial Internet context, the manufacturing industry has received particular attention. While manufacturing is on the front line, other industrial sectors are also transitioning towards just-in-time production, processing and delivery of new products and services. Business operations, in the new model, rely on the actual demand rather than on traditional predictions. It has even been claimed that the days of "lean manufacturing" are gone; companies have to become "leagile" (lean and agile) (Karnouskos et al., 2014; Mohamed et al., 2011; Nieuwenhuis and Katsifou, 2015) or exit the marketplace. This new term implies

continuous analysis of production lines, suppliers' actions, stock and production capacity to best respond to changes in demand.

Analysis among 20 countries worldwide confirms the positive forecast regarding IoT technology-based business contributions to the economy. Transition to IoT-enabled products and services is predicted to unlock contributions of US$10.6 trillion to GPD by 2030 (Purdy and Davarzani, 2015).

Forecasts also indicate savings opportunities and increased efficiency. In 2013, Cisco estimated that supply chains and logistics that build on IoT solutions could realise savings of $2.7 trillion through improved efficiency and reduced waste (Cisco, 2013).

In Finland, the latest forecast of economic growth and productivity by Pohjola (2014) presented the productivity growth potential and its elements (Figure 32). After recovering from recession and seeing a more efficient use of ICT, the Industrial Internet is seen as a major growth productivity potential element.

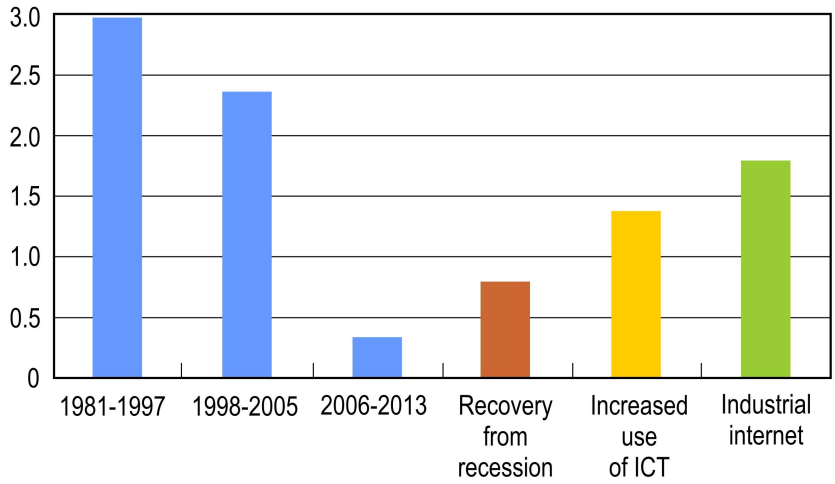


Figure 32. Productivity growth elements in Finland [Adapted from (Pohjola, 2014)]

It may be argued that these forecasts and expectations are too optimistic. However, by understanding the maturity of the existing communication or sensor technologies, in addition to the available data fusion, analysis and visualisation technologies, it can be stated that the required technology already exists and is becoming economically exploitable on a large scale. While business opportunities beckon, based on the new business models and concepts, it is important not to underestimate the technology developments that are still required.

4.1.2 Industry expectations and challenges

A Canadian survey, conducted in 2014 among 209 medium-sized and large Canadian organisations, clarified the IoT solutions that companies have implemented, the benefits they have experienced, the importance for business and the lessons learned.

Greater productivity and improved quality of service were ranked equally as top benefits by all industry sectors, except retail, where improved security was ranked as the most important benefit achieved (IDC InfoDoc, 2014).

Top IoT benefits by industry	Greater productivity	Increased quality of service	Improved security	Greater reliability	Cost savings	Faster decision-making
Manufacturing	#2	#1				
Primary (including oil/gas)	#2				#1	
Distribution	#2	#1				
Retail			#1	#2		
Financial services	#1					
Healthcare	#1	#2		#2		
Government	#1					
Utiilities						#2

Figure 33. Top IoT benefits by industry [Adapted from (IDC InfoDoc, 2014)]

When evaluating the main IoT solutions developed, asset-tracking turned out to be the most common application among 22% of respondents from industrial sectors such as manufacturing, distribution, retail, financial services, utilities and government. Other business solutions in the forefront of development actions were security monitoring systems (14%), monitoring/processing systems (14%) and inventory tracking (11%). In addition, IoT-based public services and building monitoring systems are a key area. It is notable that the vast majority of the respondents felt that companies who ignored IoT-based product and process innovations were at risk of falling behind the competition. The new revenue models, business processes, models and strategies are top of the list of expected changes in the transition to IoT-enabled business. However, the best business models are as yet still under development.

A large international survey (Economist, 2013) of 779 business leaders clarified the expected impact of the IoT on their business, the forecasted changes to current operations and the chief obstacles. The survey was augmented by in-depth interviews with nine senior executives and experts. It was observed that IoT-enabled business possibilities are either discussed or sought after by 75% of companies. Respondents were united in their understanding that the IoT will have an influence on how they will run their business in the future. In fact, they already saw business

exploitation possibilities in the very near future, by 2016, a total of 96% of respondents believed they would already be exploiting business opportunities that are enabled by IoT in some respect. It is also remarkable that, in total, 61% of respondents stated that companies that ignored IoT would fall behind the competition.

What are companies experiencing as obstacles to this positive development? According to the survey (Economist, 2013) the statements revealed that companies are suffering from a lack of IoT understanding and competences both among the employees and the management. This is seen as one of the biggest obstacles to exploiting the related business opportunities. It was further determined that there is a need for a paradigm shift in attitudes regarding the entire business environment. In more tightly networked business operations in terms of products or service production, competitors may have to be adopted as partners. However, quite interestingly, the in-depth executive interviews also uncovered that only a few executives expected to co-operate with competitors as a result of the IoT. In contrast, all 779 business leaders stated that relying on partners with the necessary experience, technology and access to expertise was an ideal way to start.

How are modes of doing business expected to change during the era of IoT or the Industrial Internet? The most widely expected changes will be positive for businesses, in the form of new revenue opportunities (30%), fresh waves of innovations (23%), changes to approaches to running the business (29%) and changes in business models, processes or strategies (23%) (Figure 34). It is noteworthy that new revenue was not expected to be gained from new services, but from existing ones.

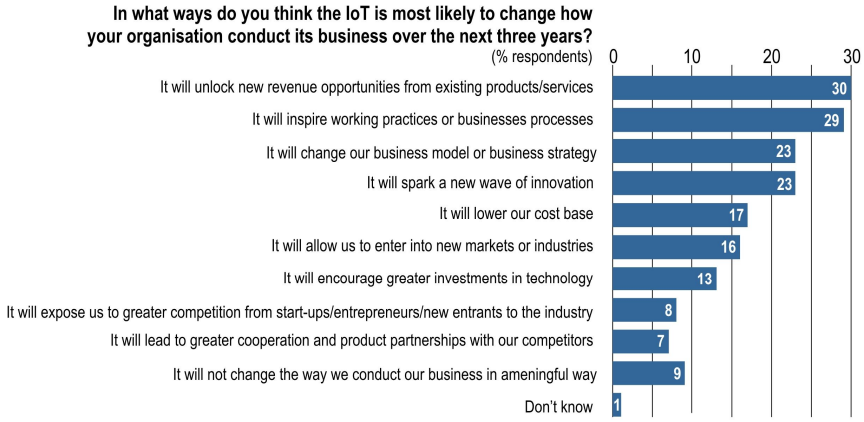


Figure 34. The expected changes to business [Adapted from (Economist, 2013)]

A study performed by the World Economic Forum (2014) clarified what were felt to be the main opportunities and risks brought by the Industrial Internet among 250 members of the Industrial Internet Consortium (IIC), through a survey and five

workshops organised in the United States, Europe and Asia. It transpired that the vast majority of companies are still struggling to understand the business opportunities afforded by the Industrial Internet. According to this survey, the opportunities can be found in four main areas:

- Improved operational efficiency through condition-based maintenance and remote management.
- The appearance of an economic outcome where the delivery of measurable and economically significant results to customers becomes a valuable business asset, instead of selling products or services. This requires a deep understanding of customers' needs and business contexts.
- New connected ecosystems that merge on software platforms, blurring the traditional industrial boundaries.
- Collaboration between humans and machines, which will lead to unforeseen levels of productivity in addition to more enjoyable work experiences.

As for the main risks and challenges that businesses and governments are required to overcome, the study identified these as compromises to security and data privacy, lack of interoperability of existing systems, uncertain risks brought by investment in new technologies, legacy equipment, immature or untested technologies, lack of data governance rules and want of needed experts. The study also clarified the opinions of business leaders in the IT industry, by asking about the three most important actions the IT industry (including hardware, software and service providers) can take to help accelerate the adoption of the Industrial Internet. The three top-ranked actions were the development of a common approach to addressing security concerns, the convergence of standards to support better interoperability and collaboration to create technology testbeds, such as for testing technology interoperability (World Economic Forum, 2015).

Industry of Things World conducted and published an online survey among 738 managers of international companies. The survey studied the impacts, challenges and opportunities of IoT implementation. In answer to the question of what was the biggest challenge for their organisation regarding the implementation of IoT solutions, 35% of respondents answered that it related to how IoT impacted their business models. Meanwhile, how to capitalise on IoT was a challenge for 24% of respondents. Lack of standardisation and technology challenges related to big data, analytics and cloud computing were the next most common concerns. Among these respondents, concerns over security (4%) and privacy (5%) were not strongly highlighted.

The biggest opportunity afforded by IoT-based business was felt to be the gaining of competitive advantages (32%) and new revenue channels (27%). Operational efficiency was mentioned by 14% of respondents and cost efficiency and savings by 9% (Industry of Things World, 2015).

An extensive survey of 235 industrial companies from five industry sectors in Germany, covering manufacturing and engineering, automotive suppliers, industry processes, electronics and electrical systems, and information and

communications, clarified the opportunities and highlighted that digitalised products and services will generate approximately €110 billion of additional revenues per year for the European industry. When clarifying the expected benefits, the German companies rated better planning and controlling as the most expected benefit (80%), as well as higher customer satisfaction (67%). The respondents also felt that increased vertical integration allows greater flexibility of manufacturing and time-to-market reduction, while better integration of the horizontal value chains leads to better efficiency. It is obvious that successful business operations, in the context of the Industrial Internet, require new value networks and business co-operation. The most important reason for tighter co-operation of companies is to achieve better customer satisfaction (59%) (Popescu, 2015).

The very recent global barometer with nearly 1,100 interviews shows that already there has been a rapid adoption of IoT by companies. From this point, if something needs done companies are thinking about how to do it; instead of being cautious, actions are being planned and implemented. From 2014, when only 53% of respondents had heard of IoT, two years later in 2016, 89% of respondents had increased their use of it in the previous 12 months. This demonstrates the enormous pace of development in the field of IoT or Industrial Internet; “76% of businesses say that IoT will be ‘critical’ for the future success of any organisation in their sector” (Vodafone, 2016).

4.2 Business opportunities and challenges

In this sub-section, the findings from the TINTTI project are related to the wider literature regarding the business opportunities and challenges brought by the Industrial Internet.

4.2.1 Identifying avenues for business in Industrial Internet

Within the TINTTI project, a central task was to bring clarity to the myriad of terminology and conceptualisations to do with the Industrial Internet, overlapping with the Internet of Things, Industry 4.0 and Industrial Internet of Things, or even Wireless Wearable Things. These terms are often used to talk about the same thing, although they carry different meanings, which impacts on how to identify avenues for business (Tihinen et al., 2016). It was concluded during the TINTTI project that the Industrial Internet is an *ecosystem*-level concept, as it also includes the role of people in new businesses, services and product development, as well as larger internet-economic characteristics. The Industrial Internet as a business ecosystem is illustrated in the following figure.

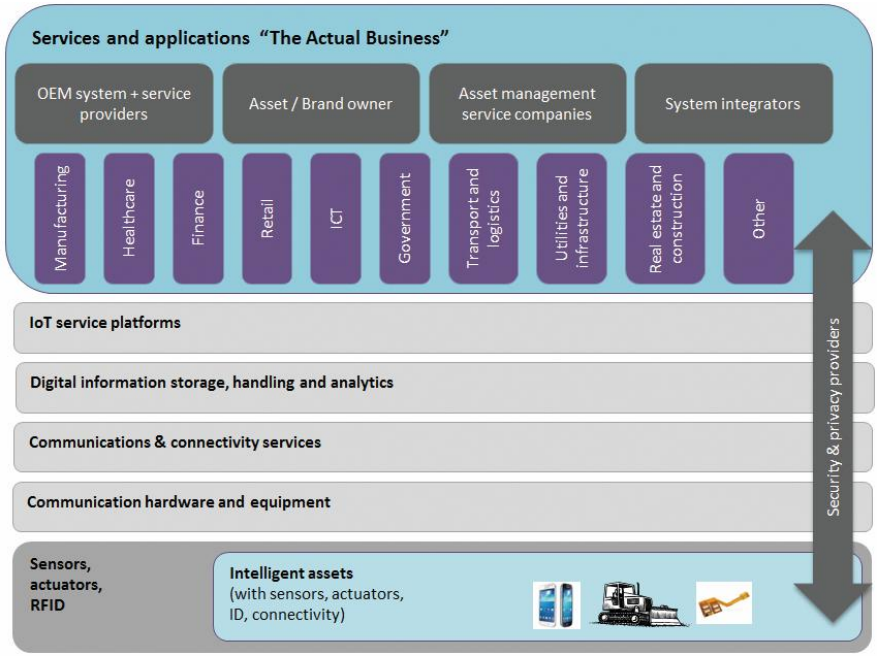


Figure 35. Industrial Internet ecosystem [Adapted from (Iivari et al., 2016)]

The constant changes in the current business environment, as facilitated by the development of ICT and IoT technologies, have fundamentally changed modes of conducting business. Products and services are increasingly being merged with digital technologies, and disentangling them from the underlying IT infrastructures is becoming increasingly difficult (Bharadwaj et al., 2013). Enabling the participation of third-party business partners through open innovation is considered an important part of new service innovations and total end-to-end service solutions. Collaboration and close interactions have become ever more essential in the pursuit of new business opportunities within the Industrial Internet, as well as for TINTTI case companies. These kinds of partnerships may, for instance, influence business directions (such as technology and domain choices) and, eventually, IT houses' long-term strategies. Therefore, an ecosystem-wide collaboration through the Industrial Internet is predicted to expand even further in importance (Iivari et al., 2016).

The role of *branding* and *awareness building* is seen as crucial, especially for smaller start-ups. This means that Industrial Internet service providers also have to act as "spokespersons of digitalisation", particularly within domains that are lagging behind in this area. The benefits of digital services and solutions must be spelled out very concretely and explicitly; references are extremely important in validating the business. Without a clearly articulated product or service, finding customers for digital solutions is a laborious task. In these cases, a company has to search, find

and build new partnerships wherein the company and a partner (perhaps a potential customer) have a common understanding of what digitalisation means for them, and goals can be set jointly.

Creating business in the Industrial Internet requires new kinds of competences, means and methods. When searching for potential customers and partners, Industrial Internet *readiness* was identified as holding a central role. The most optimal situation is where a potential customer has understood their own business potential and is prepared for Industrial Internet-based solutions. In fact, a customer must have some kind of minimum technology readiness: if all data is stored manually or located in Excel sheets, for example, benefitting from Industrial Internet opportunities is difficult, nay impossible. In these situations, transformation to a higher level of Industrial Internet readiness may be too long and time-consuming a process. Selecting a customer with low readiness is necessarily a strategic decision, and typically is not the best trial partnership.

From a technological perspective, the challenge is that older machines are simply not designed for Internet connectivity. The *integration of systems* was considered important, both as an opportunity and a challenge, as to how far integration of systems can actually go, or whether it is more about standardisation if systems are already connected, and what role companies can play in the integration process. Legal issues play a fundamental part, as they impact the pace of general development of digitalisation and transformation, with the power to both enable and hinder the pursuit of business opportunities. Laws and regulations can guide, for instance, ownership of open data or security and privacy.

4.2.2 Digitalisation requires a new way of thinking

Industrial Internet technologies should not merely be considered as add-ons; the Industrial Internet is about how to rationalise and realise business and services from the combination of data, which is different from the simple automation and retrofitting of existing systems. Therefore, organisational readiness for Industrial Internet and IoT technologies also calls for an understanding of the concept as a whole, and there must be a change in one's mindset to *service business thinking* (Hui, 2014). In the pervasiveness of digital transformation, agility and the ability to react quickly to changes in the business environment are important. Large corporations are too often bureaucratic and slow to change, which allows a head-start for more speedy start-ups and SMEs. From the TINTTI's case companies' (IT houses) viewpoint, the new business potential that has emerged from digitalisation in the Industrial Internet context has already forced them to undertake changes in their organisation. For example, firms have altered their modes of doing business; some case companies have differentiated traditional and Industrial Internet-oriented businesses, even to the point of owning organisational units. In addition, there have been more collaborative approaches to working with partners in Industrial Internet-related business. These actions have assisted companies in transforming from the traditional sector to new business.

However, knowing or predicting what kinds of organisational changes or choices would be most useful, and what should be avoided (for example, should there be new roles and/or what kind of forms they should take) has proved challenging. From the potential customer's or partner's point of view, it is important to understand or at least recognise what the customer is looking for from the Industrial Internet. For instance, a customer may either be searching for direct cost savings or the development of totally new service models. In fact, a solution is successful and vital only if it meets the customer's demands. However, it is challenging to identify customers' ultimate needs in an uncertain business environment. In practice, it is not enough to identify needs; one must also define a digital and organisational transformation path to fulfil them.

Therefore, particularly a proactive, entrepreneurial, experimental and uncertainty-tolerant mindset is required to fully benefit from the Industrial Internet. The lack of such an approach has partly been the reason why many companies have had difficulties in capturing the complexity regarding the business models of digitised products (Turber et al., 2015). This has hindered the ability to create value beyond the physical product. The technology in many cases is already there, but the difficulty has been its business application (Glova et al., 2014). Accordingly, a shift towards a service-based mindset is crucial.

Logic of value creation			Logic of value capture		
Offering	Customer needs	Role of data	Path to profit	Control points	Capability development
Stand-alone products, feature-based competition	Reactive approach to solving existing needs and lifestyle	Single point of data for future product requirements	Sell more products, economies of scale	Intellectual property, branding, commodities	Internal competences, resources and processes
Over-the-air updates, value through connectivity and synergy	Proactive approach to addressing real-time and emergent needs	Connected experiences and new services through data convergence	Recurring returns through, e.g. Subscriptions and apps	Personalisation and context, platforms and network effects between products	Collaborating with others and understanding how partners in the ecosystem "make money"

Figure 36. From product to service thinking [Adapted from (Hui, 2014)]

4.2.3 Industrial Internet calls for new and alternative business models

The impact of the Industrial Internet on business models is imminent. In the changing competitive landscape, due to the ubiquitous presence of digital solutions, it is no longer superior technology alone that succeeds, but superior business models through which companies can build a sustainable competitive advantage (Chesbrough, 2010). However, it is difficult to define or forecast what business model changes are actually required for companies. For example, as Industrial Internet solutions often include both hardware and software, should the focus be on

service business or should companies also develop physical products and service business simultaneously? These questions and challenges are in relation to basic business logic: would consumers rather buy services only (enabled by Industrial Internet) or buy services with concrete devices?

Although it has been acknowledged that digitalisation impacts business modelling, neither research nor practice has conducted extensive studies on *how* digitisation and Industrial Internet affect business models (Iivari et al., 2016, Turber et al., 2015). The mainstream business model approach has included only generic vertical and horizontal perspectives. Vertical business models have been employed, for example, by most infrastructure and technology providers. These companies believe that to be competitive, they need to create value for their customers throughout the product lifecycle; thereby, they exist in a "value creation economy" and are trapped inside their own selected verticals. The second traditional generic business model is the horizontal business model, which has been employed by most service-oriented and consumer business companies. These companies believe that to be competitive, they need to serve and hook a wide clientele and reach across different segments – and try to capture as much value from their customers as possible. This is why, for example, mobile network operators have paid so much attention to Average Revenue Per User (ARPU) as a measure of their success. These companies live in a "value capture economy" where their task is to "milk the customers" and defend their existing position against competition; thus, they become extremely cost-aware and are not as innovative as they used to be at earlier phases of their development. However, the dynamics between horizontals and verticals are changing.

The limited studies on Industrial Internet (and IoT) business models have mainly focused on technological platforms and single firm business models (Mazhelis et al., 2013), omitting the ecosystem perspective on which this publication relies. However, digitalisation transforms modes of conducting business, not only from a technological but also from a business perspective, as the boundaries of organisations, products and even industries become blurred. Therefore, this publication suggests viewing the Industrial Internet from a simultaneous value creation and capture perspective, resulting in an *oblique* business model concept (Ahokangas, 2015; Iivari et al., 2016). Oblique business models are bundled or hybrid models that combine or aggregate services from different layers of the Industrial Internet ecosystem, which can be further mirrored against an early exposure to market. This recently emergent business model concept has been employed by fast-growing and service-oriented companies that rely on collaboration and utilise the external resources of third parties as part of their platform solutions. Therefore, the value is always co-created, co-captured and shared.

The ecosystem perspective on Industrial Internet business models covers the position of solutions against the scale and scope of the ecosystem, as well as the phase of development and the stage of the solution's lifecycle in relation to the ecosystem as a whole. Accordingly, TINTTI case companies are interested in, and have experimented with, new and alternative business models that they can use and apply in their businesses. From a potential customer or partner viewpoint, it is

not only challenging to find the best potential partner with sufficient Industrial Internet readiness, but also the timing should be right. Therefore, timing is one challenge. That is why it is important to be active in pilot and trial cases: all kinds of prototypes and demonstrators are very important for finding the best potential partners and testing the validity of the business. They are also useful for guiding business modelling, as traditionally business models have only been thought of at the product phase. Early exposures to markets and business model experimentation have positive effects on the commercialisation of developed solutions. Furthermore, early exposure helps to create industry standards, which will pave the way for huge volumes of production through early mover advantages.

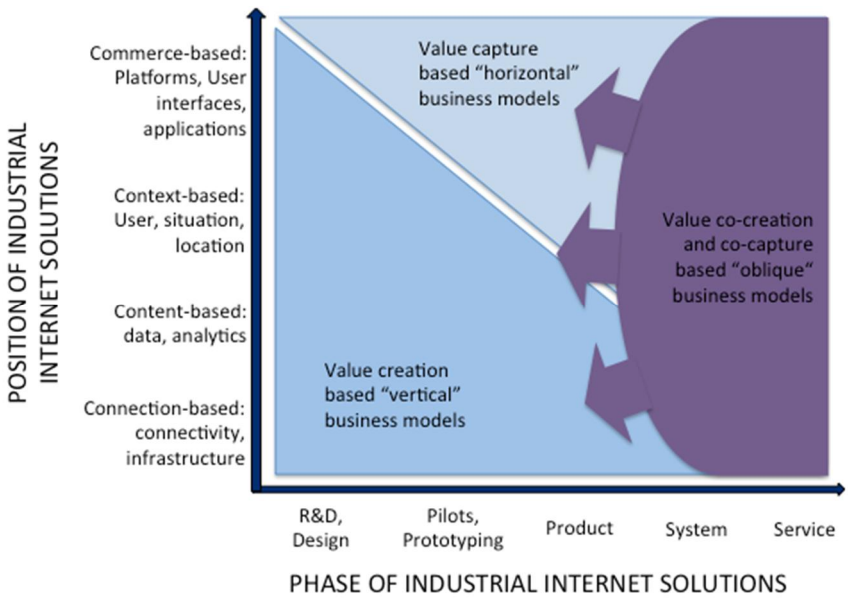


Figure 37. Oblique business model expands vertical and horizontal boundaries

Many apps and web service providers, such as Google, AirBnB and Uber, have used this kind of platform-based business model to enter the market. Apple's iPod was among the first products to create an oblique business model by basically combining a memory stick (product) with content (service) and distributing it to the masses: cheap hardware with very versatile content, bypassing completely the more old-fashioned music distribution logic employed by the music industry. With the emergence of the sharing and platform economies, where resource efficiency plays a crucial role, the oblique business models really started to thrive. Through value sharing, an ecosystem's underutilised assets are put to more efficient or better use. With the introduction of more dynamic, localised sharing approaches, non-

traditional players within the Industrial Internet, such as utilities, railways or healthcare providers, have been able to consider new ecosystem roles to strengthen their core business. The number of oblique business models is increasing fast, transforming, and converging whole industries, winning market shares and jeopardising the established or incumbent companies' horizontal and vertical business models, as small start-ups are also able to gain a foothold in the Industrial landscape through digitalisation.

4.3 Business transformation

As discussed in the introduction and in the report by ETLA (Juhanko et al., 2015), the transformation from legacy systems to Industrial Internet-enabled systems is a prerequisite for retaining competitiveness in the future. This transformation entails substantial change, not only in applications but also in infrastructure and operations. There are several issues that should be considered in the transformation in order to take full advantage of the possibilities the Industrial Internet concept can provide. At the moment, while technologies, standards and structures of the field are still maturing, there is no one right way to carry out the transformation. In fact, it has been pointed out that digital transformation of business is such a new phenomenon that "no company has yet reached the end state nor definitively defined it". Nevertheless, some best practices and key technology enablers can already be outlined. In this chapter, we highlight the vital elements for the success of the transformation and examine the related challenges.

4.3.1 Digital maturity

Digital maturity can be regarded as the goal of transformation. The Research Report by MITSloan (Kane et al., 2015) extensively reviewed the digital business maturity of companies. The report defined maturity based on to what extent digitisation has transformed the processes, talent engagement and business models of an organisation. The following issues were found to be key indicators of companies' digital maturity:

- Clear and coherent digital strategy incorporated, with the ability to articulate the value of digital technologies to the organisation's future
- Comfort in taking risks and embracing failure as a prerequisite for success
- Investment in organisational capabilities

Interestingly, the digital technologies are not the main focus: "*The strength of digital technologies – social, mobile, analytics and cloud – doesn't lie in the technologies individually. Instead, it stems from how companies integrate them to transform their businesses and how they work*". Actually, concentration on technologies may even hinder the achievement of digital maturity, as "*early-stage companies are falling into*

the trap of focusing on technology over strategy", "*having a decidedly operational focus*" and "*improving efficiency and customer experiences as objectives of their digital strategies*". Instead, in maturing companies, technologies are seen more as means to achieve strategic ends and "*business transformation is a directive of their digital strategies*".

Yet, one valuable perspective to transformation is found in the survey on the main obstacles to digital maturity, illustrated in Figure 38. As shown, the lack of a strategy is most obstructive to early and developing companies, whereas security issues become a greater concern for maturing digital companies.

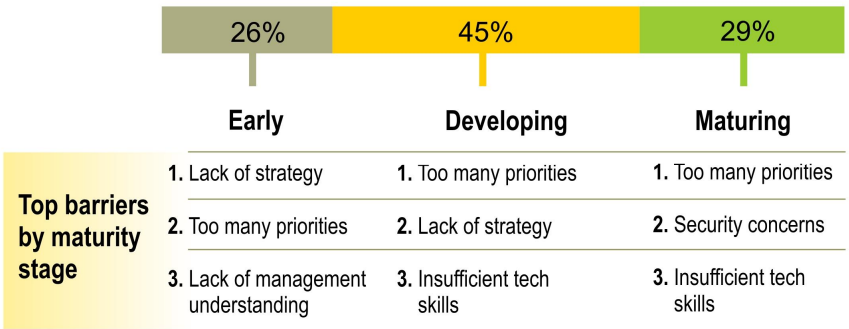


Figure 38 . The main obstacles to digital maturity [Adapted from (Kane et al., 2015)]

It can also be stated that digital transformation needs to come from the top in order to "*lead a technology-based transformation instead of just doing technology initiatives*".

4.3.2 Challenging areas of transformation

Some strategic and organisational challenges related to transformation were already mentioned in the context of digital maturity. Based on the literature review and project use cases, we have outlined some of the potentially challenging aspects of digital transformation:

- Organisational issues
- Business model
- Society and policies
- Technology
- Measurement
- Research challenges

These areas and some examples related to them are shown in Table 1.

Table 1. Challenging areas of transformation (excerpts from literature and from the TINTTI project use cases)

References to literary sources used in Table 1 and 2 (in parentheses) are available at the end of this sub-section, 4.3.2.

Challenge area	Examples based on literature	Examples based on use cases of the TINTTI project
Organisation	• Processes in companies have been optimised for old business models (1) and traditional metrics, e.g. for services that don't support digital transformation (3) • Difficulty of deciding what to transform first (customer relationships, internal operations, business model…) (3) • Lack of capabilities, competences and skills for realising the industrial digitisation with full effect (4) • Organisational and institutional infrastructures, including skills, top management support and business processes, are difficult to put in place because they involve social change (5) • Attitudes of older workers; they may not want to deal with technological change (3) • A company's internal politics, including an employee's fear of losing power in the organisation and an absence of incentives connected to digital transformation (3) • New forms of work and collaboration: Collaborative Manufacturing, Collaborative Engineering, Crowdsourcing, Crowd Funding and Open Innovation (5)	• Companies' metrics for business don't support new value chains • ICT companies can't make investments with long term ROI
Business model	• Lack of clarity about the pay-off (3) • Problems concerning agreements and responsibilities of a new business model as well as securing own business (1) • The complex ecology of actors shaping the IoT (5)	• Ownership of data • Challenges in pricing and pay-per-use business models • One's business models is dependent on other actors; how to find the right partners • Responsibilities for different stakeholders; contract technique • Lifecycle of a product • Customers' readiness for solutions of Industrial Internet (II) and their willingness to pay for II services

		• Productisation • Customers are often more interested in cost saving than in new business possibilities
Society and policies	• Uncertainties of public policies that may undermine the pace and significance of innovations around the IoT (5) • Trust-privacy "tension", i.e. absence of data impedes trust as accountability is limited, but data gathering creates trust problems regarding the use of the data in question and intrusions on privacy (6) • IoT might transform the Internet into an increasingly inhuman artificial society, deepening divides between those without access and the Internet-enabled users (as well as nations) (5) • In HC, the digital divide could be reversed, with those less well-to-do managed by things and those more well-to-do able to deal with people (5) • Policy issues concerning spectrum management and roaming (7)	• Regulation and legislation
Technology	• Multiplicity of technology platforms and their incompatibility with each other (1) • Legacy technology which is complex to update and connect to a new technology (3) • The evolution of IoT technologies is in a hyper-accelerated innovation cycle that is much faster than the typical consumer product innovation cycle (8) • Inertia, complacency and human capacities hinder keeping up with the pace of technologies (3) • The Internet bandwidth can get saturated with data traffic of proliferating devices, creating system-wide performance problems (8); emphasised in safety-critical systems (9)	• Overly complicated solutions are not attractive • IoT platform / middleware winners • Cloud vs. on-premises solutions • Security • Product liability • Appropriate openness and visibility of data • Evaluation of maturity of a new technology • Worry about overloaded Internet / 2.4 GHz band slows down • Worry about radio-magnetic radiation that is found to be harmful to health
Measurement	• Difficulties in measuring latencies between "things" operating at multiple frequencies and supporting multiple generations of standards (10)	• Measuring the benefits of transformation to II-enabled systems

Research	• The lack of case studies and experience with scale; often new constraints show up when the scale is increased (7)	• Industrial Internet often left as isolated experiments of R&D departments

In addition to the more general challenges of transformation described above, technological challenges are discussed in more detail in the following section. Although these concerns are not necessarily the most critical in early phases of digital maturity, their significance increases as the transformation progresses. Furthermore, advanced technological solutions and their combinations may turn into a significant competitive advantage or even the basis for a completely new business. In the study by Bandyopadhyay (2011), key technologies involved in the Internet of Things are presented. The same classification is applied while listing challenges related to these areas from the viewpoint of transformation (Table 2). Similarities with the transformation issues found in use cases are found.

Table 2. IoT technology enablers and transformation challenges related to them.

IoT technology enabler	Transformation issues based on literature
IoT architecture technology, software and algorithms	• II-enabled architecture must support scalability, modularity, extensibility and interoperability among heterogeneous things (11), (12) • How to design a common underlying software fabric for different environments and how to build a coherent application out of a large collection of diverse software modules (11) • Designing an SoA for IoT is still a great challenge, in which service-based things might suffer in terms of their performances, including cost (13) • A lack of a commonly accepted service description language makes the services incompatible in different implementation environments (13) • The burden of legacy systems (3), (13) • "Holes" in the information chains of companies, both vertically within firms and across the value chain (4)
Communication and networking technology, network discovery technology, relationship network management technology	• Extensive design space (e.g. mobility, network topology, connectivity, QoS requirements) makes application development a complicated process (11), (7) • Trade-offs between power consumption, range, throughput and expected lifetime (7) • Need for very fast response time in some II-based systems (1) • The scalability of the Internet and Web to handle a trillion things in a reliable way (9) • Failover capabilities: if a network fails, users want a backup solution (7) • Developing automated discovery mechanisms and mapping capabilities in order to enable dynamic, run-time configuration of connections (11)

	• Managing distributed databases, repositories, auto-polling of network devices and real-time graphs of network topology changes and traffic (11)
Hardware technology	• Developing and fabricating sensor nodes very cheaply, also taking e-waste issues into account (14) • Miniaturisation of hardware and nanotechnology (8)
Data and signal processing technology	• The level of data management in companies is relatively low (1) • In the process industry, information is more closely tied to the physical production flows to the extent that it cannot be separated (4); this stresses the importance of well-designed data models • In the future, few enterprises would be able to invest in data storage that is sufficient to house all the IoT data collected from their networks (8) • Traditional data mining techniques are not directly applicable to unstructured images and video data (8) • A shortage of competent data analysts (8)
Power and energy storage technology	• Rechargeable, environmentally friendly power supplies for sensor nodes (14)
Security and privacy technologies	• Lack of security and privacy will create resistance to adoption of the IoT by firms and individuals (8) • Privacy concerns, insufficient authorisation, lack of transport encryption, insecure web interface, inadequate software protection (15)
Standardisation	• Not enough resources to integrate various contributions into a consistent, coherent whole (12) • Competing standards (8)
Identification technology, discovery and search engine technology	• Enforcement that IDs of connected devices are not cloned, copied or forged in order to enable reliable authentication (7) • A lack of a powerful service discovery and searching engine (13) • The development of lookup or referral services to link things to information and services, considering both privacy and confidentiality (11)

The list of potential challenges is lengthy, and could become even longer.

References used in Tables 1 and 2:

(1) (Juhanko et al., 2015)
(2) (Kane et al., 2015)
(3) (Fitzgerald, 2015)
(4) (Larsson et al., 2014)
(5) (Dutton, 2014)
(6) (Guerra et al., 2003)
(7) (OECD, 2012)
(8) (Lee & Lee, 2015)
(9) (Zittrain, 2013)
(10) (Nelson, 2015)
(11) (Bandyopadhyay & Sen, 2011)
(12) (Barnaghi et al., 2013)
(13) (Li et al., 2014)

(14) (Mukhopadhyay, 2013, 2014)
(15) (Hewlett Packard, 2014)

4.3.3 Opportunities

While there are still obvious technological challenges, the vast potential of the Industrial Internet clearly makes it worth considering. A roadmap of key technological developments in the context of the IoT application domain, by Gubbi et al. (2013) is introduced in Figure 39. As shown, a number of interesting technological advancements are expected to take place in the near future.

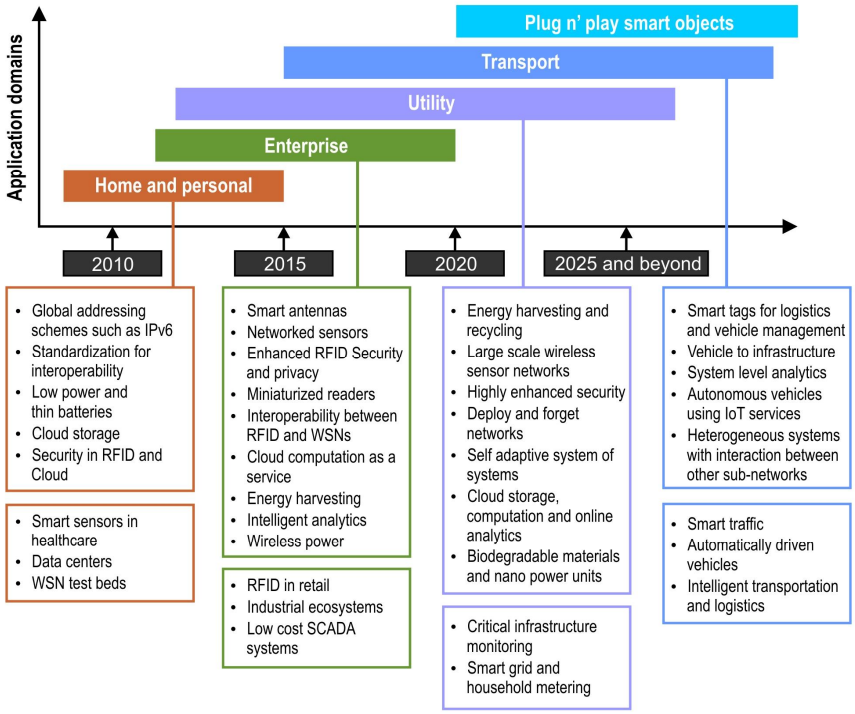


Figure 39. Roadmap of key technological developments in the context of the IoT application domain [Adapted from (Gubbi et al., 2013)]

These enablers, combined with those brought by other aspects of digitisation (shown in Figure 40), may provide unprecedented business opportunities. Miorandi et al. (2012) categorised the ways in which IoT opens up new opportunities as follows:

i. By bridging vertical markets, giving rise to cross-cutting applications and services, based on the use of a common underlying ICT platform

ii. By enabling the emergence and growth of new market segments and applications, made possible by the ability, provided by IoT technologies, to interact with physical objects via digital means

iii. By optimising business processes by leveraging advanced analytics techniques applied to IoT data streams

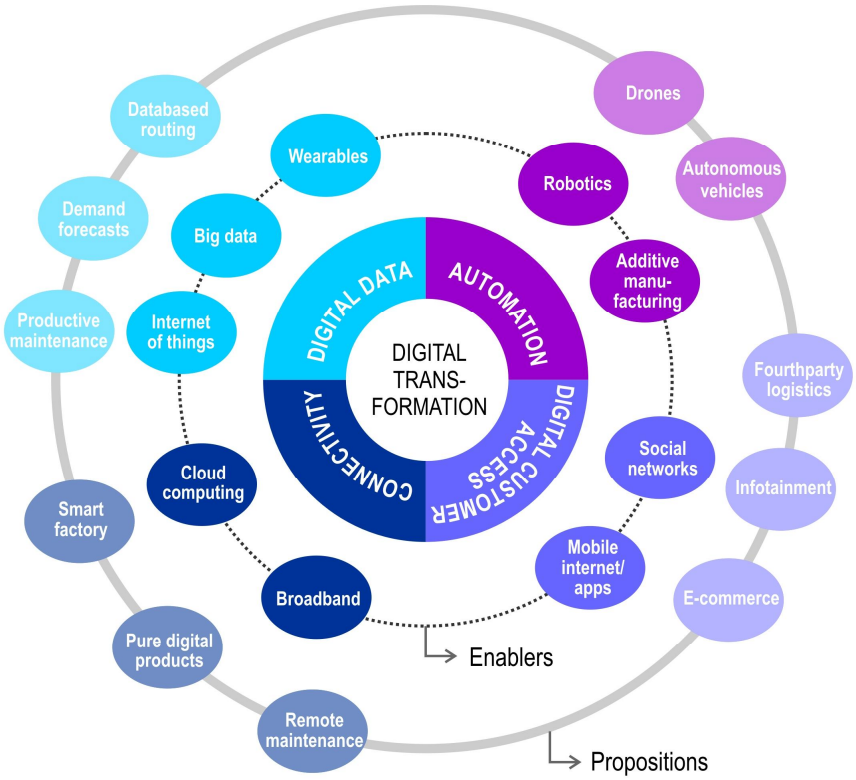


Figure 40. Drivers for digitisation [Adapted from (Roland Berger, 2015)]

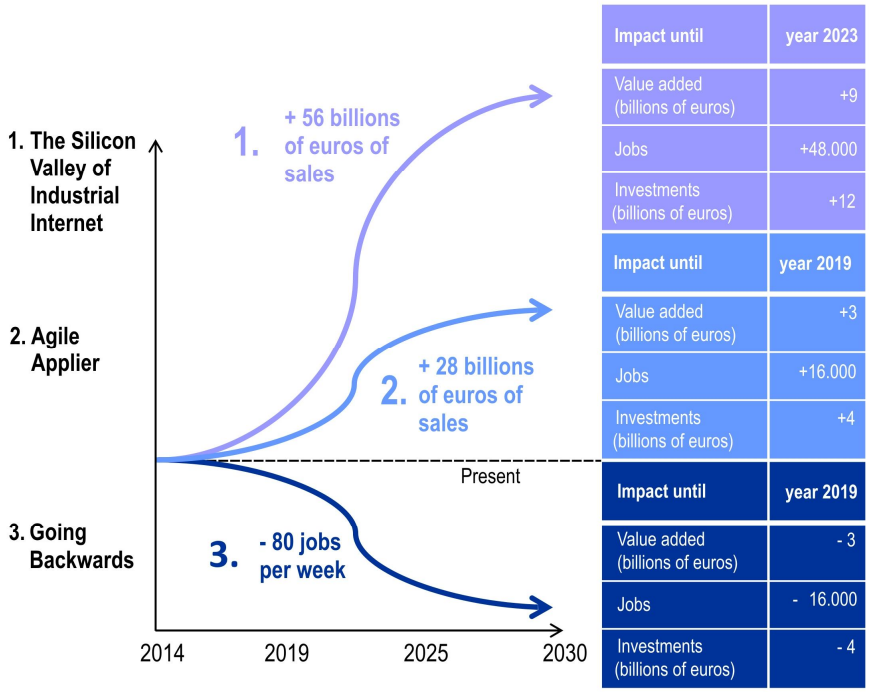
In fact, the development and implementation of IoT technologies is not only a source of possible new revenue, but also a prerequisite for retaining the competitiveness of the company in future. There are various predictions regarding the possible scenarios in the Finnish industry, depending on to what extent the possibilities of the Industrial Internet can be utilised (shown in Figure 41). In the most positive "Silicon Valley" scenario, Finland takes a role as a key actor of platforms (both technological and business) and ecosystems of the Industrial Internet. In the Agile

Applier scenario, Finnish companies and other stakeholders are not necessarily key actors, but are still able to rapidly and efficiently utilise the Industrial Internet in their business.

In order to make these positive scenarios a reality, five main action areas are presented in which the government, as well as companies and stakeholders, need to co-operate purposefully:

1. Leadership and implementation
2. Access to the market
3. Market and business models
4. Know-how
5. Technologies and platforms

Concrete actions related to all five areas are also proposed. With regard to technologies and platforms, the building of piloting environments while paying special attention to security issues is seen as a most natural way to create a competitive advantage for the Finnish industry.



Impact until	year 2023
Value added (billions of euros)	+9
Jobs	+48.000
Investments (billions of euros)	+12
Impact until	**year 2019**
Value added (billions of euros)	+3
Jobs	+16.000
Investments (billions of euros)	+4
Impact until	**year 2019**
Value added (billions of euros)	- 3
Jobs	- 16.000
Investments (billions of euros)	- 4

Figure 41. Possible directions for the Finnish industry [Adapted from (Ailisto et al., 2015)]

4.3.4 Initial steps towards digital transformation

Larsson et al. (2014) proposed initial steps towards industrial digitisation in the process industry, based on literature and their study of the Swedish industrial automation sector. First, they presented major gaps that need to be addressed; interestingly enough, these gaps are very much related to the identified challenges within the TINTTI case companies, shown in Table **3**. In addition, it is worth noting that Larsson's gaps are very similar to the main obstacles to digital maturity (Kane et al., 2015).

Table 3. Major gaps of industrial digitisation by Larsson et al. (2014) and key challenges identified by the TINTTI project.

Larsson's major gaps	**Key challenges identified by the TINTTTI case companies**
1. Low awareness on a corporate management level concerning the strategic importance and impact of industrial digitisation	Readiness / understanding of business potential
2. Under-investment concerning systems and methods for integration in the value-creating systems	Organisational choices and new roles
3. Low awareness concerning business models' potential to transform technological possibilities to business values	New or alternative business models
4. Lack of capabilities, competences and skills for realising industrial digitisation with full effect	Organisational choices and new roles

Larsson introduced a three-layer model, which was applied to each of these four cornerstones in order to take the first steps towards digital maturity. The steps are described in Table 4.

Table 4. The first phases towards digital maturity, according to Larsson et al. (2014).

Phase towards digital maturity	**Steps to take in this phase**
(A) Measure and assess	A benchmark exercise on both company and sectorial levels, indicating the current strongholds, weaknesses and potentials on strategic and operative levels
(B) Educate, spread and inspire	Form structures for knowledge dissemination and experience sharing
(C) Activate	Direct research development and innovation efforts on process, technology, competence and business integration, enabled by digitisation

Based on the interviews in the TINTTI project, the importance of these steps has mainly been recognised in the ICT companies, and some efforts to consult these steps on the part of customer companies have been made, for example as a part of the ICT companies' IoT offering.

In addition to offering new kinds of IoT consultation services, other forms of transformation were also identified among the case companies. For the most part, the development of IoT /Industrial Internet-based products and services had been included as a part of the companies' strategy. New IoT teams had been founded in order to enhance Industrial Internet efforts and lower the barriers between existing teams to enable the convergence of the IoT-related capabilities. Naturally, new skills, especially in data management and security, were needed.

Cloud services are acknowledged as an integral element of the Industrial Internet. Some of the case companies used cloud-based data storage, and it was widely agreed that currently the amount of data coming from sensors is very limited and is not putting pressure on the size nor cost of storage solutions. Nevertheless, the scalability of cloud was appreciated because it was considered likely that the quantities of data will significantly increase in future.

In the case companies, transformation towards offering Industrial Internet enabled services has also affected customer charging models. As companies start offering services instead of products, continuous, such as month-based, charging methods are becoming more and more common. Pay-per-use methods had also been tried out in some cases; however, continuous payments turned out to be problematic for some customers.

Partly relating to charging, changes to sales methods must also have been carried out in the case companies. As selling an Industrial Internet-based system usually requires thorough investigation of a customer's existing system architecture together with their future needs, the sales process of an II-based system is more complicated compared to traditional systems, naturally causing extra costs that should be able to be included later in the price of an implemented system. Based on the interviews with case companies, it can be argued that the sales process of an II-based system requires more awareness-raising on the part of the customer, and may even call for the customer to be assisted in accomplishing some of Larsson et al.'s (2014) steps described in the previous section. The challenges herein thus relate to finding profitable ways of selling, drawing the line between selling and consulting, and increasing the skill requirements of salespersons.

5. Digital transformation in practice

This section describes the first version of the digital transformation model, based on an article by Parviainen et al. (2016). This model will be tested and refined in future research projects and complemented with the capability model. The capability model can be used to position a company in its route to digitalisation and to provide steps on how to proceed systematically in digitalisation.

5.1 Need for a digital transformation model

Digitalisation has been identified as one of the major trends that will change society and business in the near and long-term future. The impact of digitalisation will be major; it has been compared to the Industrial Revolution by several authors (Economist, 2012; Degryse, 2016). It causes changes at several levels:

- Process level: adopting new digital tools, streamlining process by reducing manual steps,
- Organisational level: offering new services and discarding obsolete practices, offering existing services in new ways
- Business domain level: changing roles, business models and value chains in ecosystems, and
- Society level: changing society structures (such as type of work, means of influencing decision making).

Even though the importance of digitalisation has been realised, companies are often struggling to understand the potential impacts and benefits of digitalisation for their own processes. The main issue is how companies can tackle this change. Digitalisation is dramatically impacting firms' ways of working and their business environment. Neglecting digitalisation will result in a risk of losing business in highly competitive markets. Digitalisation can have impacts on a company's entire operational environment and on its internal way of working. Digitalisation can bring new business opportunities, business models, change the roles of operators in a value chain and end existing business. For example, it may remove traditional intermediaries in the supply chain and create new ones. This can be due to, for example, direct access to consumers and the increased use of mobile devices or creation of new kinds of ecosystems (Iivari et al., 2016).

The impact of digitalisation, and thus the goals of digitalisation for an organisation, can be seen from three different viewpoints. Adopting well known strategy triangle principles, these three impact viewpoints can be presented as shown in the next figure.

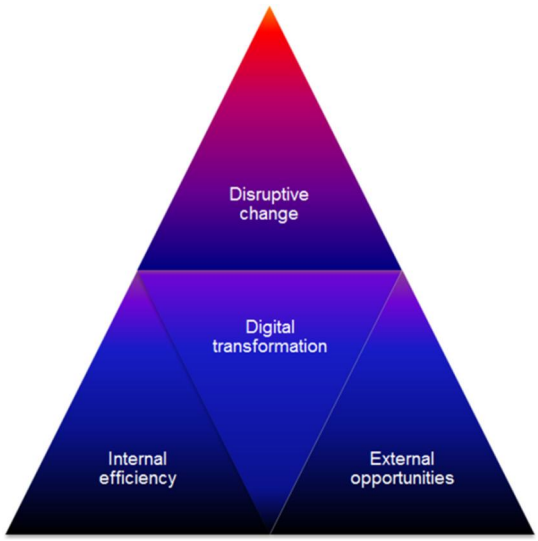


Figure 42. Digitalisation impact (Parviainen et al., 2016)

1. **Internal efficiency**, improved way of working via digital means and re-planning of internal processes.
2. **External opportunities**, i.e., new business opportunities in existing business domain (new services, new customers etc.)
3. **Disruptive change**, digitalisation causes complete changes to roles and business

There are lots of expectations, but how can digitalisation be implemented in a company in practice? VTT has developed a model by which threats and opportunities related to digitalisation can be assessed in a systematic manner, and digitalisation methodically introduced to the company's operations and products phase by phase. This model will make the company more aware of the development of digitalisation within its own sector and better prepared for the change required by digitalisation in its own business operations.

5.2 Digital transformation model

The importance of digitalisation is becoming understood, but the question now is how to do it in practice in order to best benefit from it. Based on the experiences from the case companies, we have derived a model for tackling digital transformation in a company (**Figure 43**). The model follows commonly known plan-do-check-act principles for improvement at high level.

Figure 43. Model for tackling digital transformation

The first step is to analyse the potential impact of digitalisation for the company and decide on the position that the company wants or needs to take in the change. The second step is to review the current state of the company with respect to the desired position and impact of digitalisation and identify the gap between the current situation and the desired future. The third step defines the approach that needs to be taken to close the gap from the current state to the desired position and defines the concrete actions needed to reach the wanted position. The fourth step is about implementing and validating the actions. The model is used iteratively to gradually build the solution and fine-tune digitalisation goals and plans, if needed. Next, each of these steps are discussed in more detail.

5.2.1 Positioning the company in digitalisation

This step is divided into four sub-steps: digitalisation impacts, digitalisation drivers, digitalisation scenarios and digitalisation goals. In order to define the position of the company in digitalisation, the digitalisation impacts for the company should first be analysed. This is done by identifying and analysing current and upcoming trends of digitalisation and the relevance of these trends to the company's business domain. How far along the business domain already is in adopting these trends should also be analysed. The trends can be categorised using SWOT analysis into topics that are strengths or weaknesses; that is, whether they can create opportunities or present threats in the business domain. This analysis sets the basis for positioning the company in digitalisation.

Next, digitalisation drivers should be identified for the company, using the trend analysis results. This is done by looking at the relevant trends for the business domain, and analysing their impact on the company. The importance of each of these drivers should be defined in order to scale the next steps. For example, if the driver is that the business will end without changes, the actions should be radical.

Based on the driver analysis, potential scenarios for the company's future should be analysed for the most important drivers. This is done in order to understand the potential impact of digitalisation for the company. As discussed in the section "Impact of digitalisation", these impacts can be related to internal efficiency or external opportunities, or be disruptive. Alternative scenarios for digitalisation are identified and analysed. This analysis involves evaluating the cost of implementing the scenario, the benefits of implementing the scenario and risks involved in both implementing and not implementing the scenario. Based on the scenario analysis, the best alternatives are chosen for the company.

The final task of this step is to define the goals for digitalisation of the company by analysing the selected scenarios and their feasibility for the firm. These goals can be very different in various situations, depending on the potential impact of digitalisation for the company. For example, the goal can be utilising a technology for faster operation, or complete renewal of business. When the goals are defined, they should be formulated to business-related indicators through which the improvements can be evaluated against the baseline situation and further improvements can be defined. Digital transformation is not a one-time exercise for a company; instead, it is a continuous adaptation and streamlining to meet the changing demands of the business environment.

The result of this step is the goals for digital transformation of the company.

5.2.2 Review of the current state

In this step, the current situation of the company is analysed from the viewpoint of the defined goals. This step is divided into two sub-steps: analysis of impacted areas and analysis of the situation with respect to the goals, First the impacted areas are analysed; that is, the issues that are related to the goal are identified. In the case that the goal is related to the internal efficiency, the related processes, tools and resources are identified (these more detailed elements of the areas are called issues). If the goal is related to external opportunities, such as customers, competitors, internal resources and processes are identified. If the goal is related to disruptive change, it is likely that the entire firm will be impacted.

When the impacted areas are identified, their situation with respect to the goal is studied in detail. The questions to be answered vary based on the goal:

- If the goal is internal efficiency, the questions to be answered are related to the currently used practices.
- In the case that the goal is related to external opportunities, the questions to be answered are related to the business case.

- In the case that the goal is related to disruptive change, the questions are related to all the company's areas.

As a result, a detailed description of the current state with respect to the digitalisation goal is described.

5.2.3 Roadmap for digitalisation

In this step, a detailed plan for reaching the goal is defined. This step is divided into four sub-steps; identifying the gap between the current state and the goal, planning the actions needed to close the gap, conducting a feasibility analysis and prioritisation, and roadmap creation. First, the gap between the digitalisation goal and the current state is determined in detail. In the case that the goal is related to internal efficiency, the current state of the processes and used technology is analysed against the goal, and needed changes identified. In the case that the goal is related to external opportunities, the definition of the gap involves definition of the work that needs to be done to develop the offering for the new customer or segment, including needed competences, development work and possible changes in current offerings. In the case that the goal is related to disruptive change, the gap analysis involves defining the current issues (competences, offerings) that can be utilised in the new situation and identifying the lacking issues that need to be acquired.

When the gap is defined, actions to close the gap should be defined. In the case of an internal efficiency-related goal, the actions can be putting new technologies (such as IT tools) into use, optimising existing processes or re-defining processes using digital opportunities. When improving internal efficiency with digital opportunities, the current way of working should not just be digitised, but should be defined so that the digital opportunities are used optimally. This analysis should consider which processes would have the highest potential to benefit from digitalisation, and the criticality of these processes to business. Key performance indicators (KPIs) should be re-evaluated and updated to better meet the new business targets. In the case of external opportunities and disruptive change goals, the actions could involve defining and developing new offerings, acquiring new competences, analysing potential new markets and rearranging internal resources.

When the needed actions are identified, their feasibility should be analysed and they should be prioritised. Feasibility analysis involves, for example, cost-benefit analysis, impact analysis on existing practices, offerings and resources, risk analysis and analysis of constraints. Common costs of digitalisation include the technology needed for digitalisation, training and support for staff involved in digitisation work and maintenance of digital data. In addition, as digitalisation involves change, all common costs related to changing the way of working apply. Part of the feasibility analysis can be trials and prototypes of the potential solutions in order to gain a deeper understanding of the actions needed. Then, the actions are prioritised, considering dependencies between the actions and views of relevant stakeholders. The organisation's ability to change should also be considered, so that it does not try too much or too little at a time.

When the actions are prioritised, they can be arranged into an actual road map, defining their order, importance and responsibilities.

5.2.4 Implementation with technical support

This step is about implementing and validating the actions defined in the roadmap. It is often useful to first implement proofs-of-concept when new technical advancements are attempted. As this step is highly dependent on the goals and planned activities of the previous steps, there are no generic sub-steps identified.

Digital transformation involves a change, and thus all facets of change management should be considered – including managerial disputes about the nature of advancement; a socio-cultural challenge resulting from the organisational effects on the involved people, which may lead them to react against those changes; and a technical challenge, which is due to the difficulty of understanding and adopting a new technology.

The validation of the actions should involve analysis of whether the actions lead to desired impacts and taking corrective actions in case they do not.

5.3 Next steps

The development of the model will continue. The leading idea is to help companies systematically advance in digitalisation. Our future research focuses on the phenomenon of digital transformation and how it can be managed and implemented in a systematic manner in organisations so that:

- threats and opportunities related to digitalisation can be assessed in a systematic manner by the company and
- digitalisation is methodically introduced to the operations of the company and its products step by step.

We aim for a solution consisting of a model and related support services that make the company more aware of the development of digitalisation within its own sector and better prepared for the change required by digitalisation in its own business operations.

The model will be applied and refined in real-life industrial cases and complemented with the digitalisation capability model. The capability model can be used to position a company in its route to digitalisation and to provide steps on how to proceed systematically in its adoption.

6. What next – back to the digital future

The company use cases and the research results discussed in this publication show adequately how the means of digitalisation are considered and taken into use. There is a vast blue ocean of opportunities still available. It is important to recognise the elements that allow digital transformation to happen and what affects the choices of the businesses of the future. More than ever, companies need to be aware of multi-technological developments, since this is key to creating new offerings in the short term; for example, how to use sensor technologies, software and back-end systems in a well-orchestrated manner. At the same time, new business opportunities must be identified and a roadmap for viable service businesses created.

Based on the survey conducted in 2016 by VTT and the University of Oulu on behalf of the Oulu Chamber of Commerce, well over two thirds of the nearly 100 respondents indicated that they will invest in digitalisation during the coming twelve months. (Oulu Chamber of Commerce, University of Oulu & VTT, 2016) Moreover, almost all expected to increase their investments in the future. Most of them would address the internal functions and the external value chains in which they participate, and looked especially for better utilisation of customer-related data in both. Remarkably, only very few were interested in services as such, and not that many in the change of products to services. Digitalisation of existing processes and offerings was therefore a priority, but with data to be acquired from the customer side.

Cost savings and better process management were seen as key drivers for this sort of digitalisation, but marketing, customer satisfaction and business innovations were pointed out too, as well as elimination of redundant work, faster feedback, access to business networks and even the question of having a sufficiently modern enough image. On the contrary, making use of communities in value creation was not considered very important; neither was digitalisation seen to result in very fast commercialisation of the offerings. These certainly differ from general expectations, but correlate with the responses that too little is as yet known about how to deploy digital solutions in practice and how to benefit from them in terms of business results.

The cloud, digital platforms and smart devices were referred to by the respondents as the key enabling digital technologies, compared, for example, to the rapidly proceeding virtual and augmented reality solutions, which were hardly mentioned in relation to digital opportunities. Appropriate competences, usability issues and the availability of financing for investments were brought up as potential hindrances to the emergence of digitalisation. In addition, some respondents were afraid that digital benefits would be swamped by the costs of platforms, so that the impact for their own businesses would only be moderate at best.

6.1 Interoperable data-based services

Digitalisation is already everywhere, but its meaning is somewhat open as regards the role that it is expected to play. On one hand, there is a long history of automated data processing, but on the other hand digitalisation is seen to refer to a deeper transformation in which formerly distinct markets, businesses and offerings become reshaped through data-based interoperable services.

Most of the past and many present information systems have been developed and are still being used in silos, be those technological, product-based or market-oriented. Although the Internet and Web have started to break up such silos, progress was relatively slow, at least before the cloud became available through smart devices. A clear reason is that the number of devices has practically exploded, but perhaps even more importantly, the emergence of all kinds of services has taken place based on the availability of digital data. There has often existed useful data that had not been digitalised yet, or that was recorded and then transformed into digital form by hand every now and then, rather than gathered and managed digitally in real time.

Ideally, digitalisation provides for new business innovations, better customer service and cost savings at the same time, while scaling businesses up rapidly and thus resulting in remarkable profits. In many cases the starting point has, however, more often been efficiency in terms of reduced process expenses than effectiveness measured by market penetration and customer satisfaction. Agile and lean principles emphasise rapid process throughput with continuous customer feedback, but they may still not always ensure the sharing of all valuable data. Standardisation of data access and exchange interfaces, as well as open data management schemes are meant to prevent monopolies or silos built on data.

Digitalisation will potentially not only break vertical silos, but also cut across the horizontal layers of technologies and enabling infrastructures, thereby providing interoperability. Due to this development, the structure of the information technology industry itself is likely to change, as well as that of many of its customer industries. The block chain technology, as an example, is expected to cause plenty of turbulence in the financial industry. Importantly, both systems and people may become more loosely coupled, based on data and not on pre-defined architectures, processes and interfaces. Instead, some functionality may be taken care of by new parties, when access to digital data becomes available. An important reason is the scalability of digital services that are location-independent so that their production and consumption locales are not tied together. This also means that services are more readily exportable, or actually that they are export-import-independent.

6.2 Towards a platform economy

There are several needs and concerns regarding digitalisation in industry and businesses and among individuals, mainly dealing with what investments it would

require and what benefits it would bring, if any. In general, many end-users expect immediate and “free” value from digital offerings and are not willing to pay anything upfront, and not much for specific usage sessions.

It may happen that the value of an enabling product must be covered by the earnings of services requested by the users on a demand basis, or that a flat rate must cover all the life-time expenses of a combined offering. Platforms play a central role in bringing value consumption and creation together, and often in real time. It is obvious that use-centred access platforms will proceed, although new technology and functional platforms may emerge, for example, for digital data to be gathered in small quantities from everywhere.

In order to create a case for industrial interoperability platforms within value chains, companies in a business ecosystem must deal with data sovereignty. Who owns the data when it is produced for a product, including many subcontractors? The benefits to the customer are clear; if accurate data is provided to the producers, the customers will enjoy a better service in the future. However, deals between participating companies must be resolved; do they trust on mutual contracts, or is there a need for general contracts or even legislation? EU’s “Free flow of data” initiative is a top-down look at this issue. While the process is now ongoing, it will, in time, affect how companies are going to manage and make business out of data.

This is currently more a political initiative than a concrete roadmap, but eventually a political vision may become legislation, which will switch the business environment into a higher gear. Examples of related directives are the payment services directive PSD2 and the general data protection regulation GDPR. It can be foreseen that such directives reform the business environment. The position of banks at the centre of financial services could be disputed, and rules of data ownership may thereby concern many different industries.

6.3 Digital scenarios

Many of the foreseen growth areas based on digital technologies cover wider domains than particular product and service markets. These include, for example, green solutions, urbanisation, climate change, and future community infrastructures. However, it is expected that some specific market segments are digital forerunners, whereas other are traditionalists, if not laggards. As an example, in the energy market, the smart metering, billing and load-balancing segments are envisioned to make use of digital solutions at a faster pace than the energy storage sector.

A slightly different view is to consider people, services and platforms as the key elements of any emerging digital market segment. Mobile and cloud technologies would be used to gather and integrate digital information from many different sources for interoperable offerings. The initial digitalisation era based on electronic marketing would thereby develop towards more comprehensive and seamless solutions and ultimately to automated and intelligent services. During this

development, many “vertical” businesses would change to “horizontal” and then to “oblique”, meaning that value sharing is their basic characteristic.

Based on this logic, it is possible to outline four different scenarios for the digital future, in which either companies or people are at the centre and digital solutions are either being mainly used or produced: ICT-driven digitalisation – focus on companies and production of digital solutions; business-based digitalisation – focus on people and production of digital solutions; self-made digitalisation – focus on people and use of digital solutions; and industrial digitalisation – focus on companies and use of digital solutions. (Ahokangas et al., 2016.)

Obviously all four scenarios are proceeding at the same time, but it is a matter of choice as to which of them to support. As an example, the fourth scenario assumes that industrial companies would benefit from the use of digital solutions, but would not themselves be the main supplier of such solutions. To simplify, Germany is behind the industrial digitalisation scenario, USA is a forerunner in business-based digitalisation, Finland among some others looks for ICT-driven digitalisation and self-made digitalisation is fighting against authorities and existing businesses.

There is still a business gap between the ICT-driven and the business-based scenario, meaning that customers have not yet often been taken into the digital value chain as active value-creating parties. Correspondingly, industrial companies may suffer from a technological gap that can hamper or slow down their investments in and profits from digitalisation. Compared to both of the abovementioned scenarios, many individuals and communities are not professionals in regard to new technologies, and therefore they have a gap as regards the production of digital solutions. We have also witnessed a cultural gap between many existing businesses and the crowds of proactive and productive people. It is more challenging than ever to make them interested, and especially to keep them around.

Each of the four scenarios will now be briefly addressed.

6.3.1 ICT-digi – disruptions via new opportunities

ICT-based digitalisation is driven by a number of market opportunities ranging from healthcare and wellbeing, energy, finance and industrial production to people’s everyday needs. An important driving force is certainly also the start-up business boom that has been witnessed, especially after the year 2008. Digital technologies are evolving rapidly and there is an almost limitless innovation potential in them.

A slowing factor is, however, that the former infrastructures and ecosystems are still much in place, although often under some turbulence. Moreover, competences may be missing, for example from data analytics. Although many companies have introduced services associated with their products, these may have been built mainly for marketing or after-sales purposes and not based on more comprehensive and new digital service strategies. As a consequence, their scalability may be poor and the actual role in bringing profits quite modest – they can even be provided “for free” in connection with products. This is also often related to the capability to serve many customers, for example tens of thousands as opposed to a few hundred.

There is also a danger that independent, technologically innovative companies are acquired at a very early phase by much bigger and established players that put their developments on hold, because they do not want to have new, competing solutions in the market, or that at best reduce the role of the acquired company to a small technology development site. A technological starting point for a new digital business may, in general, be too narrow a view. It may also require investments in research and development that are not available to individual innovators or very small teams.

6.3.2 Business digi – transformation of products to services

Business-based digitalisation has proceeded visibly in many areas, not least in social media, entertainment and gaming, but also in many consumer, market and even public services. What was earlier considered as electronic commerce is now something different from home webpages and simple Internet-based product ordering. In fact, a massive change has taken place in terms of all kinds of services that replace or come along with products.

Legal and safety concerns, but especially the need for renewing existing strategies and operation models, are the challenges faced when digitalising businesses. It is striking that in some cases, public bodies have been forerunners in providing seamless service chains based on an entirely new logic, rather than private companies. As an example, a person can in Finland get his or her passport, which is one of the most trustworthy documents around, just by visiting a photo shop and then picking up the passport from the nearest R-kioski store. Everything else can be managed through a digital service available through a smartphone or a laptop.

This sort of servicification may create opportunities very rapidly for new or extended businesses. One successful business case or even a person, be him or her the fresh Chief Digital Officer or an enthusiastic social media character, can turn the wheels towards the digital era. However, for well-established businesses, the change may be demanding, at least in terms of being able to follow fast-moving consumers. They evaluate alternatives and make their choices on the Internet, order the chosen items directly to their homes very cheaply and quickly and return any unsatisfying purchases to the supplier at no cost.

6.3.3 Self-made digi – users as producers

Self-made digitalisation has reached almost everyone in terms of mobile smart devices and the cloud. Web streaming technologies have already changed consumers into producers and made them free to access contents and services almost any time and anywhere. All kinds of community efforts and situations in which people must be mobilised have benefitted from digitalisation. Formerly non-

existent platform-based digital services, such as Uber and Airbnb, have managed to make enormous numbers of resources readily available and at the same time have caused plenty of turbulence. Although Linux challenged Microsoft and others as an open operating system “owned by everyone”, the effects of the mentioned and other similar platforms are many times bigger. They do not involve only developers and advanced users, but potentially everyone.

Public services have not yet met floods of digitalised citizens in the role of service producers. Moreover, the governance of self-made and community services is still underdeveloped; there exist both legal barriers and cultural prejudices towards the possibilities of individuals to act as occasional businesspersons, as well as considerable quality and safety concerns. The occasional digital micro-entrepreneur often runs a local business as a hobby, without any intention or possibility to scale the business up or even to build a new full-time profession from it for himself or herself.

Thinking of the emerging digital opportunities from the strategic development perspective, the self-made digitalisation scenario is still almost non-existent. It is not yet considered as an organised arena towards which research funding, joint innovation agendas and coordinated development activities would be targeted – despite its practically unlimited number of “prosumers”.

6.3.4 Industrial digi – deep transformation of the industry

Industrial digitalisation has been largely based on the vision to provide seamless interoperable processes, from design to maintenance, based on the acquisition, analysis, management and deployment of digital data. It may be correct to say that in this regard, the focus is on the heart of digitalisation.

Digitalisation may, however, considerably affect the existing business models and earning logic of product vendors and system suppliers, and thereby decrease their interests in renewal. One way to overcome the problem is to share the initial costs with others, by developing and piloting new solutions with customers or business and research partners.

Another problem may be that digitalisation is used to revitalise and not to revolutionise the existing businesses. This can, in practice, result in a slow or at best sporadic digital transformation, compared to strategic renewal of key value networks as a whole. In the worst case, digitalisation is reduced to the adoption of yet another new production management or parts- and products-tracking software application.

Investments in industrial digitalisation can also be hampered because of lock-ins to existing systems and data or difficulties in either making incremental changes or adopting new solutions at once. Influential experts, key customers, executive managers and company owners may not be ready to launch digitalisation agendas because they do not want to cause difficulties to ongoing businesses, and third parties may not have the power to change this kind of attitude.

6.4 Summary

Regarding the discussed scenarios of digital futures, ICT-driven development is the most likely direction in Finland, and perhaps also the most wanted. Industrial digitalisation can be seen as supporting this development, because it would result in interoperable processes and new data-based service businesses. However, in segments where two-sided markets emerge, such as in energy production, it may be the case that new businesses are also built to support micro-producers, who could institutionalise into co-operatives or similar new sharing ecosystems.

Globally, digitalisation is likely to proceed based on business opportunities created by more pervasive customer needs and more radical changes in the overall market regarding new entrants, increased competition and agile ways of serving customers. Service design, management and provisioning would be connected to logistics, but not always to production and design. Instead, digital platforms could develop towards co-creation environments, so that their users would associate themselves with business parties and even with public bodies.

Self-made digitalisation is already a reality, but to what degree it will affect developments remains to be seen. What has already been shown is that people have much more power than expected, and that ultimately it will not be possible and profitable to prevent them from becoming digitally enabled value co-producers. Those businesses that have managed to set up new positions in relation to individuals have already shaken the thought-to-be rock-solid grounds of their competitors.

7. Conclusion

The aim of the TINTTI project was to help IT companies in developing new service business in the Industrial Internet domain. This report serves this aim by summarising the results found in the project and outlining a model for digital transformation. The research methods used in this work are a literature study, IoT Barometer survey and five company case studies involving interventions, where researchers actively participated in the planning and conceptualising of new digital services.

The Industrial Internet is seen as automating and rationalising operations, as well as enabling new business in the industrial ecosystem by connecting intelligent machines, equipment, users and organisations together so that decision-making can be improved by using advanced data-analytics methods. This viewpoint includes the improvement of productivity by digitising existing processes while retaining current business models or deployment of new ones. In addition, digitalisation is already impacting companies' ways of working and their business environment. Neglecting digitalisation will cause a risk of losing business in highly competitive markets. Digitalisation can have an impact on companies' entire operating environment and on their internal modes of working. Digitalisation can bring new business opportunities, change the roles of operators in a value chain and end existing business. For example, it may remove traditional intermediaries in the supply chain and create new ones.

The company cases include the concept of development of an information-sharing solution for stakeholders in a network led by a manufacturing company; a high-reliability and low-cost condition monitoring service; a study for offering better IT services for manufacturing companies entering the Industrial Internet era; developing security and privacy to protect IoT devices and services; as well as the development and first deployment of an advanced smart lighting system.

The IoT Barometer, with 57 respondents, showed that companies can be roughly divided into two groups: those already embracing the business possibilities made possible by the Industrial Internet and those who are not. For the former group, the two main reasons for using the technologies were opportunities for creating new services, products and business opportunities on the one hand, and expanding current business concepts on the other. For the latter group, the main reason for not using the Industrial Internet was a lack of knowledge of the technology and opportunities, which they want to correct by acquiring such knowledge.

The four-step model for implementing digital transformation is a systematic approach to tackling the potential impact of digitalisation for a company and to plan the actions that lead to successful digital transformation, involving both internal ways of working as well as business offerings. The four steps are: analysis of the impact of digitalisation on the company and its position after the change; reviewing the current state and identifying the gap between it and the desired position; identification of the approaches and actions needed to reach the desired position;

and finally, implementation of the actions and validation of the results. In many cases, the four steps must be iterated to achieve the best possible result.

Digitalisation, with the Industrial Internet as its manifestation in industry, is often compared to the Industrial Revolution in its significance. Therefore, it is of utmost importance for Finland – and for individual companies – to embrace the business potential offered by these trends. In this study, it was found that Finnish IT houses are willing to meet the challenge and take advantage of available business opportunities. This project hopes to help the companies in this endeavour.

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Title	**The Industrial Internet in Finland: on route to success?**
Author(s)	Edited by Maarit Tihinen & Jukka Kääriäinen
Abstract	This publication presents the key outcomes of the joint TINTTI project (IT Houses to Boost Industrial Internet) consisting of the following project partners: Absent Oy, F-Secure Oyj, HiQ Finland Oy, IoLiving Oy, the University of Oulu and VTT. The project was supported by Tekes – the Finnish Funding Agency for Innovation. Digitalisation and the Industrial Internet have become buzzwords that, in many situations, are used as umbrella terms for new business opportunities in which emergent digital technologies are exploited. Since these terms are considerably broad, it is necessary to conduct research on related topics, first to construct a framework in which to discuss the issues, and second to define the specific problems therein. This publication provides such a framework by defining the central concepts and depicting the use cases, especially in terms of how firms view the digital world of the future. These efforts are supported by the results of a study on how a chosen set of companies have seen their operating environment, business and operations transform due to digitalisation. The publication includes an analysis of the state of the art technologies and practices relating to business development, as well as the industrial needs and opportunities surrounding the Industrial Internet. This study found that Finnish information technology (IT) firms are willing to meet the challenge and take advantage of available business opportunities. In addition, the publication introduces a digital transformation model that will enable companies to be more aware of the development of digitalisation within their own sector, and be better prepared for the changes required by digitalisation in terms of its' particular business operations.
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Nimeke	**Teollinen internet Suomessa: matkalla menestykseen?**
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Tiivistelmä	Tässä julkaisussa esitellään Tekes-rahoitteisen yhteisprojektin, nimeltään TINTTI (IT Houses to boost Industrial Internet), päätulokset. Hankkeen konsortio koostuu neljästä yrityksestä sekä kahdesta tutkimuslaitoksesta: Absent Oy, F-Secure Oyj, HiQ Finland Oy, IoLiving Oy, Oulun yliopisto sekä VTT. Digitalisaatiosta ja teollisesta internetistä puhutaan paljon eri yhteyksissä. Termeistä onkin tullut muotisanoja, joita käytetään ahkerasti, kun kuvataan digitaalisten teknologioiden mahdollistamia liiketoimintamahdollisuuksia. Koska käytetyt termit ja käsitteet ovat laajoja, on tarpeen kuvata niitä tarkemmin. Tässä julkaisussa avataan keskeisiä käsitteitä ja määritellään keskeisimmät termit, esitetään kirjallisuuteen, haastatteluihin ja työpajoihin perustuva kartoitus aiheesta sekä kuvataan neljän yrityksen näkemyksiä teollisen internetin ratkaisuista kunkin yrityksen näkökulmasta. Projektin aikana on kyselytutkimusten avulla on selvitetty suomalaisten yritysten ja organisaatioiden näkemyksiä ja kokemuksia siitä, miten digitalisaatio muuttaa organisaatioiden toimintaympäristöä, liiketoimintaa ja/tai toimintoja. Tutkimuksissa ilmeni, että suomalaiset organisaatiot ovat joko jo käynnistäneet toimenpiteitä hyödyntääkseen teollisen internetin luomia liiketoimintamahdollisuuksia tai ovat yhä enenevässä määrin halukkaita hyödyntämään niitä. Julkaisussa esitellään myös kehitetty digimuutosmalli, jonka avulla organisaatiot voivat selvittää omaa digitilannettaan ja edetä systemaattisesti digitalisaatioon liittyvässä kehitystyössä erilaiset uhat ja mahdollisuudet huomioiden. Lopuksi julkaisussa tarkastellaan erilaisia tulevaisuuskuvia digitalisaation liittyen.
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