VTT Technical Research Centre of Finland

Beyond IoT Business

Kortelainen, Helena; Saari, Leila; Valkokari, Katri; Federley, Maija; Heilala, Juhani; Huusko, Jyrki; Viljamaa, Esa

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Preface

Beyond IoT Business reflects our view on digital transformation within manufacturing sectors. It aims to provide new insights into emerging possibilities and future development paths. This report is based on the experts workshop jointly organised at VTT in Espoo, Oulu and Tampere at the end of 2018. The workshop results are complemented by other materials, such as blogposts, research reports and project presentations.

Today, digitalisation has created an explosion of data, and the manufacturing sector is one of the sectors that generate remarkable amounts of data within its smart connected factories. Nevertheless, the utilisation of this sector's data are one of the lowest, as it is typically saved to closed enterprise data management systems. Unlocking the value of these data sources requires collaboration between the existing value networks of the manufacturing industry and network actors operating within data flows. There are a number of ways to use the data to build businesses, including data management, analysis and delivery. Services are the core of business based on IoT solutions and the outcome economy, where suppliers contribute directly to operational efficiency and key value co-creation processes.

We emphasise that a real impact can be gained by changing how goods are made and distributed, how products are serviced and refined, as well as how resources are shared and circulated. Furthermore, the transformation requires investment in new capabilities and skills, i.e., learning and re-learning. This is especially true for organisations that have enjoyed great success, as the disruption means that some of their current capabilities and skills become outdated.

We wish to thank everybody who participated in the workshop and person-to-person brainstorming discussion. It has been crucial to gain different views on a future beyond IoT business.

Authors

Helena Kortelainen
Leila Saari
Katri Valkokari
Maija Federley
Juhani Heilala
Jyrki Huusko
Esa Viljamaa

Introduction

In the future, the global competitiveness of industrial ecosystems will be highly based on digital knowledge-intensive solutions. Global flows of data already have a significantly higher impact on GDP growth than the trade in goods[1]. Today, digitalisation has created an explosion of data, and the manufacturing sector is one sector that generates remarkable amounts of data within its smart connected factories. Nevertheless, the utilisation of this sector's data are one of the lowest, as it is typically saved to closed enterprise data management systems.

Unlocking the value of these data sources requires collaboration between the existing value networks of the manufacturing industry and network actors operating within data flows. There are a number of ways to use the data to build businesses, including data management, analysis and delivery. Services are the core of outcome-based business, where suppliers contribute directly to operational efficiency and core value-creation processes.

New opportunities based on data and value integration are the next wave of servitisation benefitting from digitalisation (artificial intelligence (AI), analytics and robotics). The most remarkable opportunities lie in integrating different datasets and sources for intelligent (cognitive) systems, these are the most challenging ones, as they call for ecosystem level changes (Figure 1).

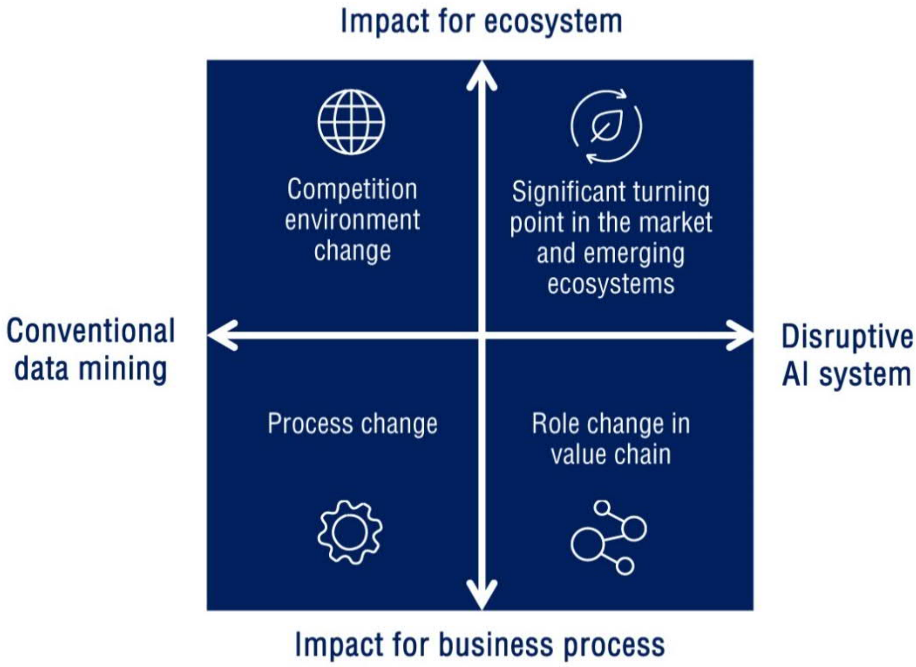

Figure 1. Business impacts framework (modified from Valkokari et al., 2018)[2].

In the future, industrial ecosystems will emerge at crossroads[3] of local value networks and operators of global data flows (for example, a loose network of an IoT ecosystem[4]). Ecosystems are interacting organisations enabled by modularity and

[1] https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/global-flows-in-a-digital-age
[2] Figure 1, see VTT Blogpost: Laurikkala et al. https://vttblog.com/2018/06/20/kurkistus-tekoalyhypen-taakse/
[3] At the crossroads of technology and business disruption, the two main dimensions illustrate changes in (1) the technical complexity of cognitive systems adopted as a continuum from big data, AI and collaborative cognitive systems, and (2) business impacts from companies' incremental improvement of internal processes to systemic changes at ecosystems.
[4] IoT's ecosystem can be defined as a loose network of interacting companies and their products and

bound together by a shared agenda that guide their collective investment. They are not hierarchically managed but dynamically co-evolving through the intentional and unintentional actions of ecosystem members.

On the other hand, the digitalization is a question of race between industrial and digital companies (IoT, platforms or other software companies) to see which ones will be the first credible actors in the markets with appropriate market value. Thus, it is also a matter of paradigm change, whether smartness is added to physical products or physical products are part of digital solutions.

Within VTT's Disruptive Businesses Lighthouse,[5] there are two opportunity pathways (Figure 2). The reasoning between these choices is two-fold. First, VTT is actively participating in European development towards a Digital Single Market (DSM).[6] A DSM is a market that ensures the free movement of persons, services and capital; individuals and businesses can seamlessly access and engage in online activities under conditions of fair competition and a high level of consumer and personal data protection regardless of their nationality or place of residence. We believe that data markets are an engrossing source for new businesses based on shared value co-creation processes. The European data market is expected to more than double in value by 2025, reaching up to 147B€.[7] Second, as Finland is an export-dependent small country, the capabilities for service business are important to Finnish industrial companies and our industrial customers operating in the global scene. During the 1990s, the amount of Finnish export services radically increased and the export shares (based on added value) were already over one third.[8]

Figure 2. Opportunity pathways of disruptive businesses.

Typically, Finnish industrial companies have strong capabilities for project-based business and service operations; together with our customers, we are looking for the next big thing after current maintenance service operations. In this report, our aim is

services that will evolve and proliferate. (HBR (2016), https://hbr.org/2016/02/to-predict-the-trajectory-of-the-internet-of-things-look-to-the-software-industry).

[5] VTT achieves world-class research and development by focusing on the identified societal challenges and growth opportunities for Finland. We call these VTT Lighthouses. Disruptive businesses are one of the topics included in the Industrial Renewal Lighthouse.

[6] The main objective of the European Commission's Digital Agenda is to develop a DSM to generate smart, sustainable and inclusive growth in Europe. The agenda is made up of seven pillars. https://ec.europa.eu/digital-single-market/en/europe-2020-strategy

[7] IDC, 2017, European Data Market SMART 2013/0063, Final Report, https://www.key4biz.it/wp-content/uploads/2018/04/SMART20130063_Final-Report_030417_2.pdf

[8] MustRead (27.4.2018): Suomen viennin rakenne on dramaattisesti muuttunut – mistä Suomi nykyään elää?

to go beyond the current Internet of Things (IoT) business solutions and explore future development paths within the emerging areas of industrial ecosystems. Building successful business innovations based on data and services calls for a visionary approach to disruptions and future markets. This requires companies to combine deep domain expertise with a thorough understanding of related digital technologies.

Industrial Internet

The Internet of things can be defined as a network of physical objects, consumer devices and enterprise assets containing technology to communicate and sense or interact with the external environment (Iivari et al., 2016). The Internet made it possible to connect huge amounts of devices and services. Figure 3 depicts three domains that depend on actor-specific digitalisation.

If the end user is a consumer, the term *Internet of Things* is typically used. Devices may be small and easy to wear or carry; they collect information from the consumer. Consumers can use the service application in the cloud from a laptop or a mobile device. In addition to using this kind of data for analysis and visualisation, there may be a feedback or control loop to control the data source device. In contrast to IoT consumer services, *Information Society 2.0* end user are citizens that connect to national services using their national identity.

In this paper, we focus on *Industrial Internet*, where companies have a view on connected smart products and services, and the users are in the role of employees or customers. Thus, future opportunities and business potential lies in the possibility to integrate these three approaches towards digital single markets (DSMs), as mentioned above.

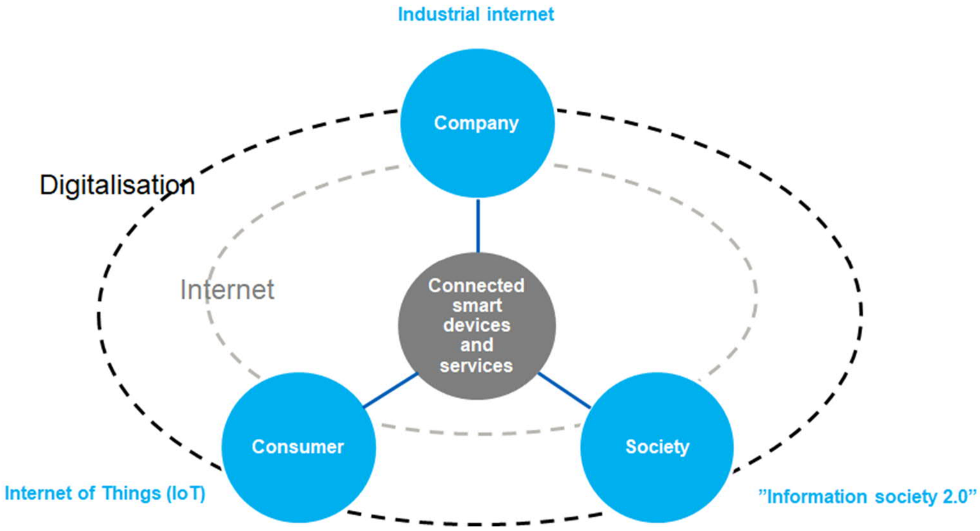

Figure 3. Three domains of connected smart devices and services (modified from Ailisto, 2015).

Data are the foundation of any connected system, and needs to be gathered, transferred and analysed before it can be exploited. The data source has an IP address and is already connected to the Internet. Data gathering is usually distributed, i.e., has several sources. Thus, before the analysis, the data are transferred via wireless connection to one place, typically in a data warehouse or data lake – a system or repository of data stored in its natural format, usually object blobs or files, i.e., without unifying the data format. Depending on the data source's intelligence, some filtering and pre-analysis can be done locally. The added value of data collected via smart connected devices lies in the analytics and user interfaces, as well as the integration of several data sources.

Different devices, servers, applications and software systems are connected through IoT platforms and/or cloud computing, making the creation of a variety of service-based business models possible. Therefore, service design will play a significant role in the future design processes of new digital data-driven services, and the understanding of customer value will play a crucial role when digital data-driven services are innovated, developed and taken to practice.

Process of Our Study

This report is based on the experts workshop jointly organised at VTT in Espoo, Oulu and Tampere. The workshop results are complemented by other materials, such as blogposts, research reports and project presentations. After the opening, nine project presentations were given. Ideas gathered during the workshop were classified according to the beyond IoT business transformation triangle (Figure 4). The corners are (i) efficiency of IoT solutions, (ii) new opportunities and (iii) disruptive transformations. This triangle is adapted and modified from the digital transformation triangle of Parviainen et al. (2017).

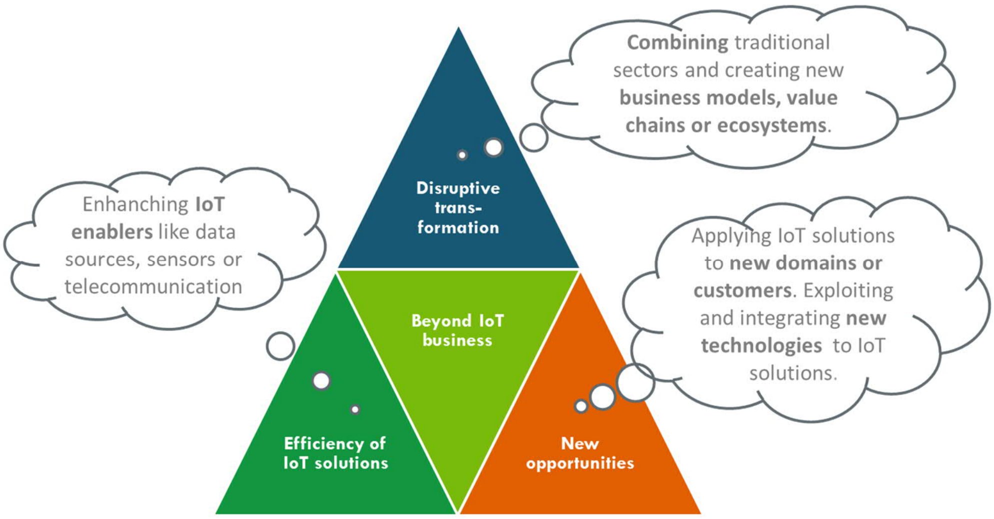

Figure 4. Beyond IoT business transformation triangle (modified from Parviainen et al., 2017).

The goal of this process was to discover especially potential disruptions, items in the top triangle. In this study, all the corners will be covered and the results of workshopping and insight of experts working at VTT are presented in the next section.

Future Industrial Internet Insights

The future Industrial Internet insights are presented and classified below within the three corners of the transformation triangle (Figure 4).

Efficiency of Industrial Internet Solutions

The efficiency of Industrial Internet solutions depends on any technological or solution enhancements that can occur before the added value generated from data gathered can be exploited. Business impacts are typically process changes, i.e., improvements in efficiency (see Figure 1). The identified key factors of Industrial Internet solutions' efficiency are highlighted in Figure 5.

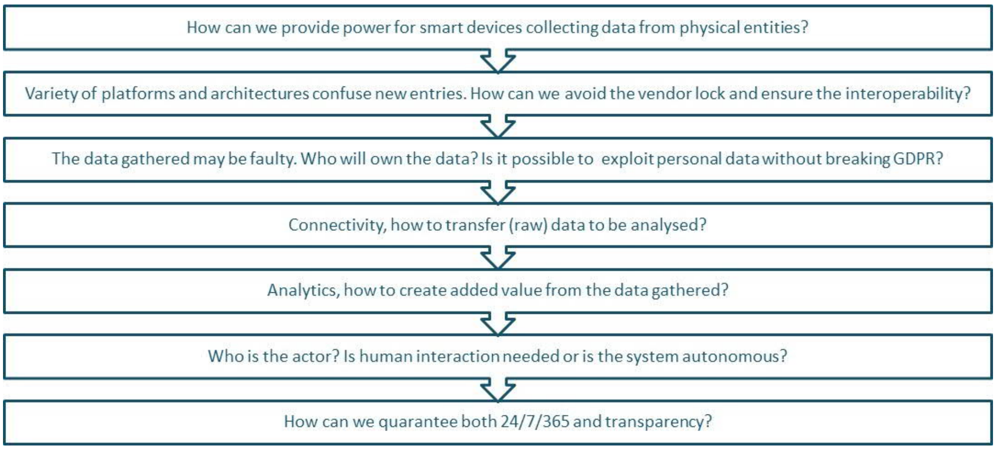

Figure 5. Key efficiency factors for Industrial Internet solutions.

Smart Devices

Data are the basis of any intelligent system. Smart devices that gather data from their environment are continually getting smaller and cheaper, and can be distributed around the site, factory, etc. Currently, the most important R&D topics related to IoT devices are concentrated on energy savings, safety and security and distributed data processing possibilities (e.g. edge computing). To solve smart devices' energy issues, topics such as energy harvesting, SW and HW energy optimisation and complete system synchronisation need to be discovered. When smart devices have increased computing capabilities, they have also caused further challenges for security of the entire system. Moreover, the processing distribution makes energy related research more complicated, as a large amount of low level nodes (smart devices) require more power. When AI enters the distributed smart devices, the optimisation of the nodes' computing skills, security and power consumption becomes even more important (Lee & Lee, 2015).

Example of the predictive maintenance case, where energy harvesting is experimented.

An excellent example of state-of-the-art IoT exploitation is Hydroline's Lifecycle Efficiency Online system, which integrates an IoT pressure and other sensing to the hydraulic cylinder for stress and wear analysis in predictive maintenance.[9] Sensors are currently wired in many cases due to high energy consumption, making wireless operation painful from the maintenance point of view. For example, the Hydroline case might be converted to wireless operation in the future with sensor energy harvesting from hydraulic pressure.

Platforms and Architecture

In practice, the heterogeneity of platforms is a key challenge that companies face. Additionally, vendor lock has been and continues to be a typical challenge of Industrial IoT solutions, especially for suppliers – which are often SMEs – operating within several manufacturing networks and customer interfaces. Therefore, architecture and applications that enhance interactions between IoT solutions are needed. Botta et al. (2016, 2) even states that 'a novel paradigm where Cloud and IoT are merged together is foreseen as disruptive and as an enabler of a large number of application scenarios'.

[9] https://www.vttresearch.com/Impulse/Pages/LEO-brings-intelligence-to-cylinders.aspx

Trust for and between IoT assets and platforms is required to efficiently build seamless data flows. The Industrial Data Space Association[10] (IDSA) is an example of the initiatives in which business and research take an active part in designing a trustworthy architecture for the data economy. More than 90 companies and institutions of various sizes and industries from 18 countries are members of the association. Another integration tool example is the data hub concept, which provides a data-centric architecture for storage that enables actors to consolidate data silos and share data in today's rapidly-evolving, data-driven world. The data hub takes the key strengths of each silo and integrates them into a single unified platform to empower the scientists, engineers and developers working with the data.

Development steps should go towards effectively connected Industrial IoT platforms that enable seamless service processes for different customers over domain borders. This also includes integration between the three domains of connected smart devices and services (Figure 3), i.e., public, personal and industrial platforms as data sources.

Data

Data are the fuel of any intelligent industrial system. Raw data from sensors can contain noise and might have strange or missing values. The phenomena need to be understood to avoid major problems with source data. If the data are retrieved from different sources, there might be different annotations (e.g. currency (€ /£) or measurement units) and semantics; visualising data is a simple but powerful tool for uncovering such problems. Usually, the raw data needs to be pre-treated (e.g. filtered) before further analysis.

Especially from the viewpoint of manufacturing companies, the industrial data (data collected via machine controllers, sensors and manufacturing systems) is often highlighted, whereas in consumer business, data produced as a by-product of consumers' actions during their everyday activities is emphasised. The rules of **data ownership** are significantly different in these cases; industrial data are typically stored in closed company (or value network) specific systems and the availability of consumer data varies in different platforms based on their rules. Often the consumer doesn't have a clear view on how their data are utilised and by whom. Therefore, the **General Data Protection Regulation** is agreed upon in Europe to build more transparent data-driven business, especially at consumer markets or markets integrating consumer data to other data sources.

Connectivity

Traditionally, networks are classified by the area they will cover (personal area network, local area network and wide area network). For small and resource-restricted devices, potential wireless communication technologies include NFC, RFID, Lora, BT, Wi-Fi and Zigbee. Nowadays, cellular communication can also be considered; the fourth generation mobile network-based narrowband IoT solutions are gaining particular interest and popularity, and are evolving quickly. There are currently two promising IoT communication solutions: narrowband-IoT (NB-IoT) and Long Term Evolution for Machines (LTE-M). NB-IoT provides long battery life and narrow mobile network spectrum usage but with the cost of mobility support and network throughput capacity. LTE-M, meanwhile, provides better capacity and enhanced support for mobility. There are currently test environments for 5G[11] and 4G LTE-based IoT networks (NB-IoT/LTE-M) available, and a flagship project towards 6G[12] has started to study beyond 5G systems.

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[10] https://www.internationaldataspaces.org/
[11] http://5gtnf.fi/
[12] https://www.oulu.fi/6gflagship/

One of the first live 5G trials for manufacturing industry

> The trial shows how companies can use 5G's ultra-low latency and high-bandwidth capabilities with video analytics to enhance and transform production in a manufacturing environment. In the trial at the Nokia factory in Oulu, Finland, a video feed of an assembly line process was monitored and analysed with a video analytics application from the Finnish start-up Finwe[13].

Transferring (raw) data from smart devices to the data storage (warehouse) is essential before any intelligence or added value can be provided. Usually, wireless solutions are used, but in a vehicle, for example, there might be wired communication bus (like CAN[14] or LIN[15]) inside. In those cases, some wireless communication is requested to enable external access and services.

Depending on the environment (e.g. cars, ships, factory environments), several different architectures can be considered for sensor connectivity, data storage and processing. In the simple use case, the sensors are connected directly to data processing and storing units. Then, the unit must be able to handle the sensors' protocol, including the raw data; only local processing and storing is needed. This is feasible when the number of devices is small and we can ensure the connectivity from sensors to processing units from the communication protocol perspective. If the data are needed outside the local processing and storing unit, in the use cases – where the number of devices is high or the total amount of data are vast – using hierarchical connection and processing architecture is often more ideal. Furthermore, in cases where protocol conversions are needed, specific gateways with protocol conversion and processing/storing capabilities are used. In the latest designs, the IoT gateway is part of the larger distributed cloud infrastructure, where the data storing capabilities are divided between gateways and global cloud. Additionally, the gateway's functionalities (e.g. protocol support, data processing algorithms, event handling and control/security functionalities) can be modified 'on-the-fly' through virtualisation technologies (Karhula et al., 2017).

Analytics

The purpose of analytics is to investigate and visualise data to enhance decision-making. Sensor signals have been used in control loops for several decades. Today, the amount of data is not the problem, although quality or integration may cause challenges. The added value of data analysis versus the difficulty of implementing any smart system can be presented as an almost linear function (Figure 6). Having the data makes it easy to look back and analyse what happened (descriptive analysis). Diagnostic analytics discover reasons for this and consider why it happens. Predictive analysis will look to the future and resolve what will happen. The most challenging analysis is to combine both foresight and action, i.e., prescriptive analytics, and find solutions to how we can make it happen.

[13] https://www.teliacompany.com/en/news/news-articles/2018/telia-nokia-and-intel-bring-5g-to-the-factory-floor/
[14] Controller Area Network is an inexpensive low-speed serial bus for interconnecting automotive components.
[15] Local Interconnect Network) a very low cost in-vehicle sub-networ.

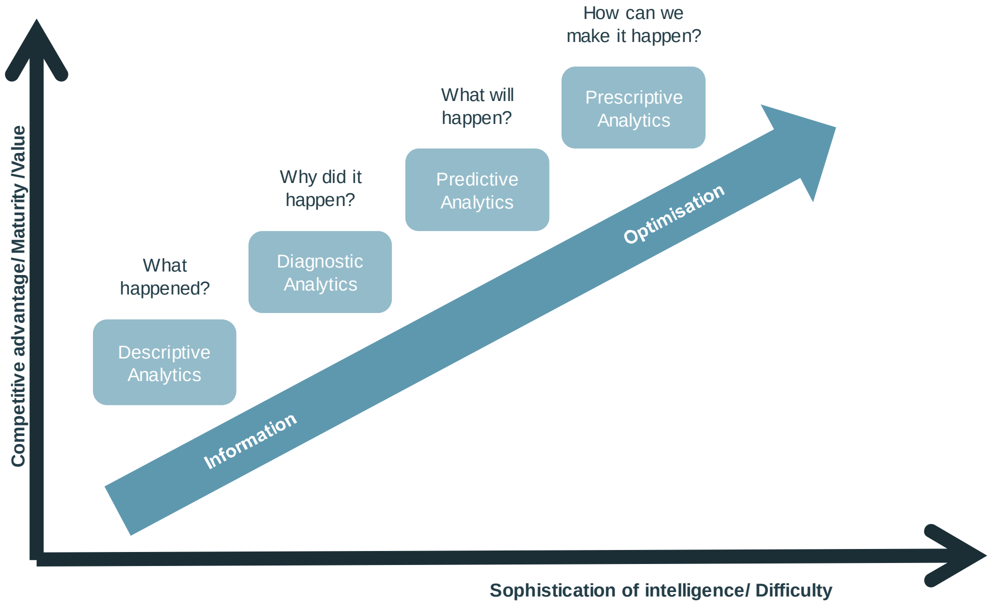

Figure 6. The value of analysis grows together with the difficulty of implementation. This viewpoint transfers from past to future (Hanski et al. 2018a, adapted from Gartner, 2012).

Big data and increased computing power are the enablers of the current AI hype. According to the European Commission, AI refers to systems that display intelligent behaviour by analysing their environment and taking action with some degree of autonomy to achieve specific goals.[16]

AI has already encountered two winters; the first was in the early 1960s, when the computation power was inadequate for neural networks. The second was in the 1980s, when logistics and set theory failed to fulfil the expectations of AI implementation. Now AI is popular again. According to Ailisto (2018), to avoid the third AI winter, we need to exploit hybrid methods, i.e., take the constraints of the physical world into account. This means that the online or real-time data shall be connected to the model of the physical world. Another issue that requires future development is the acceptability of AI solutions. More open, transparent, self-explanatory and certified algorithms will provide more ethical and acceptable AI.[17] Furthermore, the increased capabilities of (mobile) devices have created a new concept: Edge AI, which means that AI algorithms are processed locally, near the data sources. Edge AI will enable real-time AI and reduce power consumption and data communication costs because less data will be transmitted.

Human–Machine Interaction[18]

Semiautonomous robots, autonomous vehicles and service robots will do actions based on algorithms and learn to collaborate with human beings. In trend analyses of technology, *the interactive properties of AI* have been identified as the next major step in their development. A machine can learn to identify individuals and adjust its operations according to which matters the person is or is not familiar with and how he or she prefers to operate. Interaction can be further complemented by non-verbal communication, and the machine will even identify and react to the person's emotional state.

[16] European Commission Communication 'Coordinated plan on AI', 7.12.2018.
[17] https://vttblog.com/2019/01/16/the-ethics-of-ai-what-are-we-even-talking-about/
[18] Based on Eija Kaasinen's blogpost (https://vttblog.com/2018/02/22/will-artificial-intelligence-remain-under-human-control/).

In the future, we will see increasing amounts of work teams consisting of humans and robots. A robot can assist humans in many maintenance and service tasks. Fluent interaction is based on AI, which helps the robot interpret humans and its environment. Although machine learning is emphasised also humans need to learn to enhance seamless human–machine interaction. When people understand the basics of the way AI functions, they can put themselves on a level with it, in the same manner as people naturally tune into the same level with the person they are talking with.

Dimensions of Resilience, Risk and Security

In a rapidly changing, complex and interdepended business environment, companies are focusing on business resilience, which IBM has defined as 'The ability to rapidly adapt and respond to risks, as well as opportunities, to maintain **24/7/365** business operations, be a more trusted partner, and enable growth.[19] Critical infrastructure (e.g. communication and energy supply networks) resilience refers to the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to and/or rapidly recover from a potentially disruptive event.[20] With these definitions, resilience arises from excellence in risk management, contingence planning, information security and regulatory compliance. Global customers require increasingly compliant management from their suppliers that supports their activities in good corporate citizenship. Compliance management incorporates requirements dealing with issues such as safety, security, reliability, environment and transparency.

In IoT applications, information security is crucial, as potential threats do not involve privacy invasion, stealing secrets and refusal of services alone but a cyberattack on systems that rely on the Internet may rapidly paralyse vital functions of society, including critical infrastructure or shutting down or damaging industrial assets (Ailisto et al., 2015). The cascading impacts are unforeseeable. While information technology solutions provide more and more possibilities for making infrastructures and industrial assets 'smarter' and enabling extended automation of operations, it may also create new risks and vulnerabilities. Therefore, more profound understanding and tools to cope with the emerging risks and foster resilience are needed.

Safety and security also play a key role in the application of automated and autonomous machine systems. The ongoing transition from manual machines to highly automated production systems with increasing complexity set challenges for designing safe and reliable products and systems (Tiusanen, 2014). Industrial applications of partly automated (mixed-mode operation) and fully autonomous systems face system-level safety and reliability uncertainties and risks that require cooperation between the stakeholders and technological solutions. This implies that proactive analysis and system control risks are growing increasingly important (Leveson, 2011).

New Opportunities Based on Industrial IoT Solutions

Key factors about new opportunities for Industrial IoT solutions identified during the workshop are outlined in Figure 7. The business impacts of these emerging opportunities can be classified into a competition environment or network role changes (see Figure 1). In addition, two main challenges in exploiting Industrial IoT solutions were identified: (1) interoperability of processes and information systems and (2) data ownership (data sharing, quality, trust and agreements).

[19] IBM Global Services (2004) Business Resilience: Proactive measures for forward-looking enterprises. http://www.continuityforum.org/content/news/press_release/110630/business-continuity-resilience-white-paper-ibm
[20] U.S. Critical Infrastructure Resilience Final Report And Recommendations, National Infrastructure Advisory Council, 2009

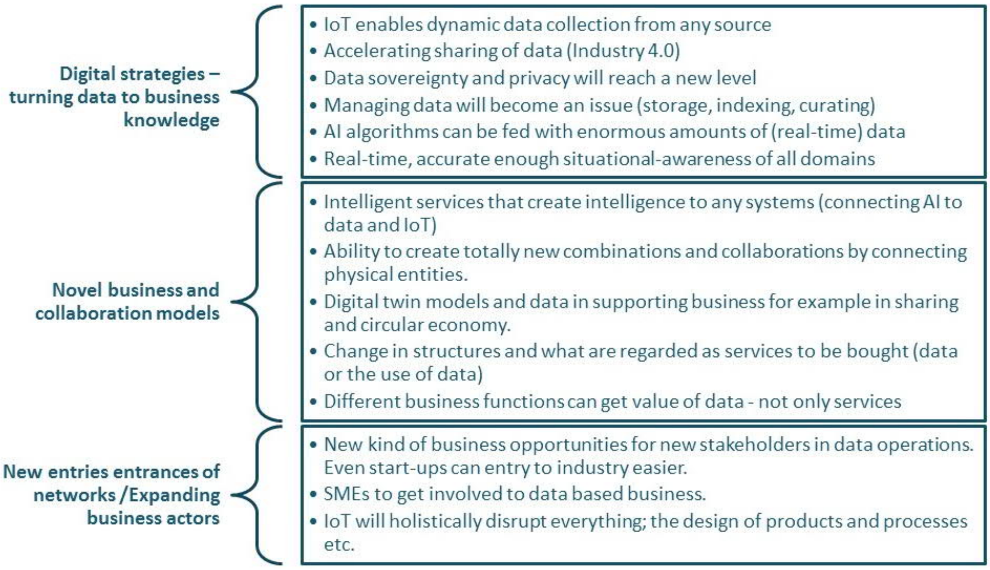

Figure 7. Opportunities emerging from the Industrial Internet solutions.

Digital Strategies Turning Data to Business Knowledge

Digital strategies at forerunner organisations go beyond technologies. They target improvements in innovation and decision-making and transform the way the business works (Kane et al., 2015). Using data, information, knowledge and analytics in decision-making and processes are at the core of this transformation process. The typical question is no longer 'What information do we need?' but 'How can we make use of the data we have?' and 'How can we integrate it to other available data sources?' Figure 8 presents this change of focus in the organisation's data strategies.

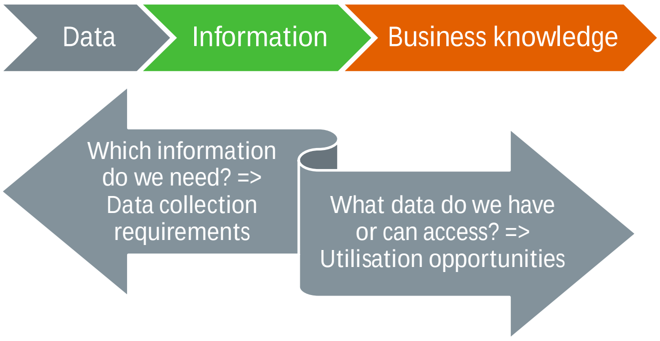

Figure 8. Before designing a new data collection, the user should make the most of the existing data (modified from Kortelainen et al., 2017).

So far, however, the adoption of new IoT-based technologies and service concepts has not met high expectations. Competition in international markets has led to a situation where industrial services (e.g. maintenance and information services) are outsourced and regional clusters have fragmented into global value chains and ecosystems in which companies specialise in specific activities (see Figure 9). The technical and economic life-cycle data of the fleet is vast, multifaceted and usually fragmented into various companies of the industrial ecosystems. The production equipment is more complex than ever. It is not feasible for each company in the ecosystem to process all data by themselves; hence, there is a need to develop innovative solutions to enable better integration, gathering, sharing and exploitation of fleet life-cycle data. This requires closer collaboration between the existing value networks of the manufacturing industry and network actors operating within data flows.

Novel Business and Collaboration Models

Data sharing adds transparency in an ecosystem and can create novel business models based on new data combinations. In industrial ecosystems, the main barrier to sharing data seems to be a strong sense of data ownership. Issues such as unclear values (transparency vs. privacy) and lack of data handling knowledge, security and understanding the data's potential create further barriers. Sharing data with other companies requires a considerable amount of mutual trust. Companies may not be ready to disclose data on the level of ecosystems, preferring dyadic transparency coordinated by a focal company. Usually, the coordination is done by the customer or based on shared rules, such as those within IDSA.

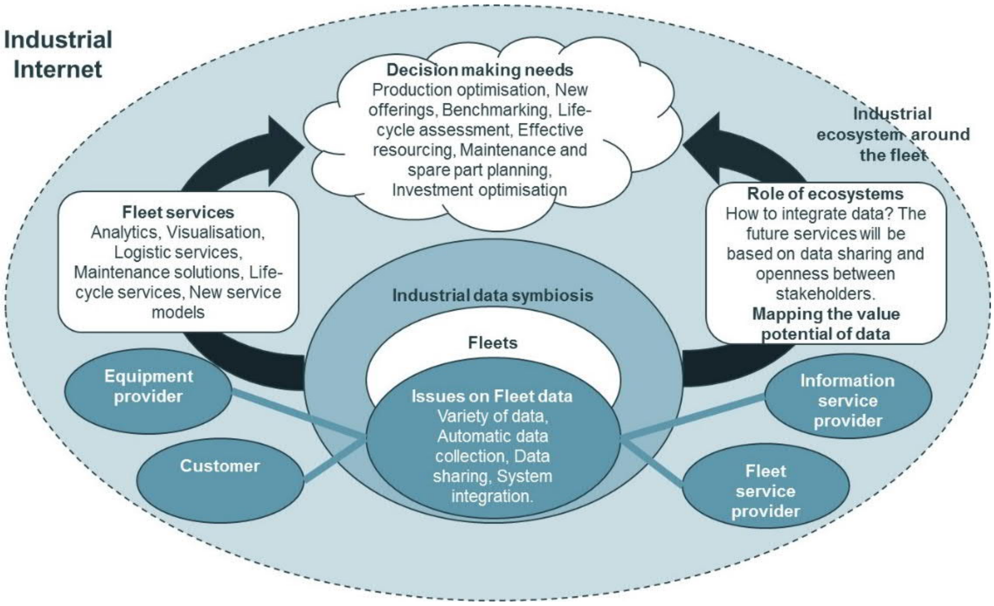

Figure 9. Industrial ecosystem around the fleet data (Kortelainen et al., 2017).

The IoT-based industrial ecosystem is not just a supply network with connected items; it is an extended supply network connecting different networks at the crossroads of the manufacturing industry and data operations. These players can be connected with the IoT solutions and thus contribute to the ecosystem's evolution. In the manufacturing industry, frontrunner lead producers aim for new ecosystems and business related to intelligent products through partnerships. More advanced companies develop innovation platforms and application programming interfaces; organise innovation contests, such as hackathons; and confer with start-ups and SMEs to provide novel content for their platform and third-party services. Although some pioneering companies have a digital service offering, most are just starting their digitalisation projects and some have not even realised the importance of digitalisation as a part of their business (Hanski et al., 2018b). Cloud services offer one practical solution for data sharing between companies at the operational level. The cloud service provider represents a third party who has no own interest in the data content but a strong interest in securing data. In case machinery manufacturers and component users have contracts with terms based on actual performance, (e.g. availability or overall equipment efficiency), data stored in the cloud ensures consistent data and calculations for both sides (Kortelainen et al., 2017).

Three examples of successful B2B platforms

In B2B application, examples of successful business platforms are scarce. One example of a business network is 365FarmNet (365FarmNet 2017). The platform offers all the information from cultivation planning to harvest, field to stable and documentation to operating analysis. Partners support 365FarmNet with their know-how and make further intelligent components available.

SSAB SmartSteel offers another example of a digital platform that enables steel to be loaded with knowledge (SSAB 2017). The idea is to share expert knowledge in steel with customers, and SSAB is now inviting more customers, process equipment manufacturers and other actors to further explore the possibilities of the SmartSteel platform.

Remote monitoring offers a wide range of business opportunities; there are also examples on successful business and companies operating globally. The companies satisfy the customers' need to forecast disturbances and failures and to estimate the remaining equipment lifetime. Successful business requires extensive potential fleets that accumulate vast amounts of data in their database and develop superior analytical skills and knowledge-based service offerings. One example is the Danish company Gram & Juhl, which has equipped over 22.000 windmill turbines with a condition monitoring solution.[21] Using historical data and key figures of performance, reliability and efficiency, data analysts can investigate and interpret the turbines' conditions.

'Digital twin' oriented IoT connects the real, digital and virtual worlds of production and serves to bridge and link real-world entities to their digital representations, i.e., 'digital twins'. The physical asset and its digital twin thus form a cyber-physical system (Lee et al., 2015). In the future, a digital twin will be created already in the product design phase from CAD models and data contained in the PDM system (Juhanko et al., 2015). Digitalisation and digital twins have already affected the design processes and application areas of simulations are strongly expanding from training purposes to provide an effective basis for design and life-cycle support (Ahonen et al., 2017).

The digital twin could be shared with supply chain partners, thus offering joint access to real-time data and accelerating the design, product manufacturing and ramp-up phases. A digital twin is concurrently synchronised with the physical system's evolving behaviour and offers up-to-date information on the asset status, also allowing simulations and predictions of future behaviour. Forerunners, such as Rolls Royce,[22] Wärtsilä[23] and companies operating in offshore industries,[24] have already applied simulations and digital twins in their design process. A Japanese company Nomoko has a mission to create sophisticated virtual worlds and spatial applications.[25]

Decision-making situations can be classified into operational, tactical and strategic decisions. This allows routine decisions on a shop floor to be separated from decisions with long-term effects on the whole organisation. At the same time, the decisions can be reactive, real-time, proactive or strategic by nature. Figure 10 illustrates the categorisation into operational, tactical and strategic decisions and the role of the data and analysis level in different decisions.

[21] https://gramjuhl.com
[22] https://www.rolls-royce.com/media/our-stories/discover/2017/simulation-platform.aspx
[23] https://www.wartsila.com/twentyfour7/innovation/edge-computing-taking-iot-beyond-the-cloud
[24] https://www.kongsberg.com/en/kongsberg-digital/news/2018/august/kongsberg%20digital%20launches%20digital%20twin%20technology%20for%20unmanned%20production%20facilities%20at%20ons%202018/
[25] https://nomoko.world

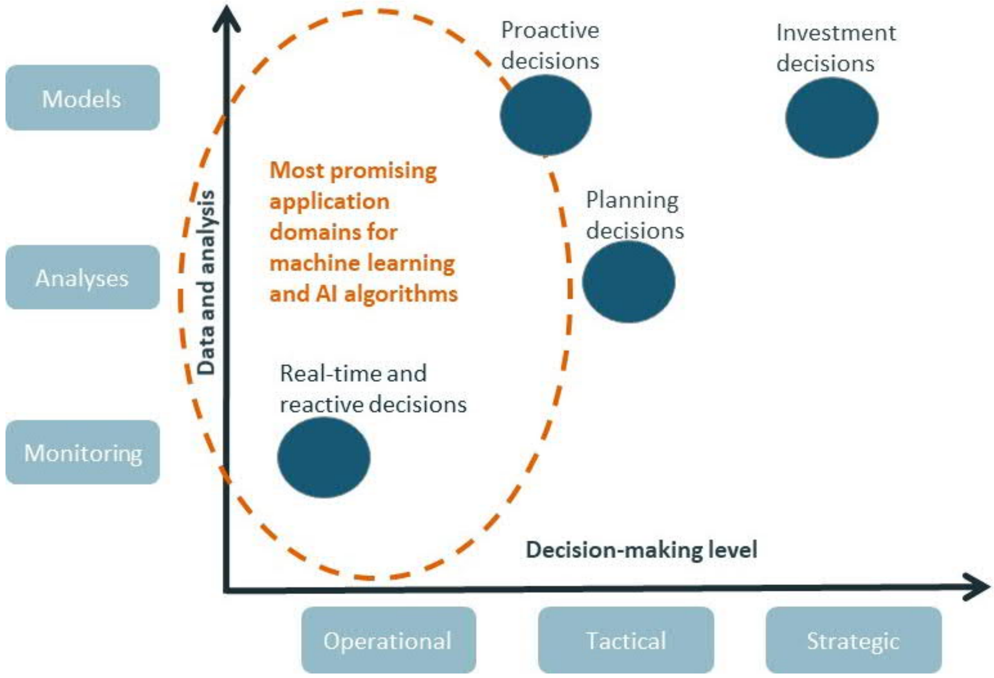

Figure 10. The nature of decision-making situations in relation to the decision-making level and the level of data and analyses (Kortelainen et al., 2017).

The recent trend has been that with increased amounts of data and modelling capabilities, predictive models can be developed to support proactive decisions, such as proactive maintenance tasks. Extended asset services refer to the extension of service delivery to long-term cooperative development of physical assets over the whole life-cycle in close collaboration with the end customer and other stakeholders. The potential for extended asset services could include features in which the service provider is capable of and has a mandate for implementing actions to improve the customer's efficiency with high business impact. The companies may update and upgrade their role in the ecosystem as an enabler, information deliverer, asset provider or asset service provider with a limited or extended offer over a wide time horizon. With the increasing capability of transforming the data into knowledge, the service provider may take more responsibility for analysing the data and making data-based decisions and planning for the customer (asset owner) (Kortelainen et al., 2017).

Self-evaluation tools for digital transformation

VTT has developed and published a tool for companies to investigate their digitalisation maturity. The tool is free and available at the VTT website.[26] The tool can be used to understand the company' digitalisation status. The maturity is assessed in six main dimensions: strategy, business model, customer interface, processes and organisation, people and culture and information technology.

A tool for discovering a company's AI maturity was published in early 2019[27] on the VTT website[28]. The AI Maturity Tool helps companies and organisations understand AI viewpoints and assess their current AI readiness and performance. The tool was developed based on the work done in Finland's Artificial Intelligence Accelerator,[29] which has been published as a part of Finnish Digibarometer 2018[30] (BF et al., 2018).

[26] https://digimaturity.vtt.fi/
[27] https://www.vtt.fi/medialle/uusi-verkkoty%C3%B6kalu-organisaatioille-teko%C3%A4lykypsyyden-testaamiseen
[28] https://ai.digimaturity.vtt.fi
[29] https://faia.fi/
[30] http://www.digibarometri.fi

New Entries and Network Entrances

Considering the new opportunities of Industrial Internet solutions, economic aspects dominate the rationale to adopt IoT in the case of 'big players' – large businesses and the public sector. Building a sole model for harnessing economic value that could accommodate all complexities of IoT implementations and many contextual issues of such deployments seems infeasible (Nicolescu et al., 2018). A typical business case is built on potential savings and risk reduction that may be achievable in resource-intensive industries (energy, process and transportation) and those that offer high enough return on investment. However, there is a clear lack of compelling and sustainably profitable business models for IoT solutions. Digital manufacturing platforms enable the provision of services that support manufacturing. The services that digital manufacturing platforms enable are associated with collecting, storing, processing and delivering data. These data either describe the manufactured products or are related to the manufacturing processes and assets that make manufacturing happen (material, machine, enterprises, value networks and – not to forget – factory workers).

Digital platforms can have different use case scenarios. The following use case scenarios have been identified in 'Connected Factory' coordination and support action project (Big Data challenges in smart manufacturing, 2018)[31]:

1. Hyperconnected Factories: networked enterprises in complex, dynamic supply chains and value networks
2. Autonomous Factories: optimised and sustainable manufacturing, including advanced human-in-the-loop workspaces
3. Collaborative Product-Service Factories: data-driven product-service engineering in knowledge intensive factories

Disruptive Transformation Based on Digitalisation

As a pervasive phenomenon, digitalisation has disruptive features that can spread throughout societies and organisations due to, for example, the continuous introduction of digital innovations embedded in services and products. Millar et al. (2018) defined a disruption as 'a change that makes previous products, services and/or processes ineffective'. Consequently, disruptive innovations are often based on a different technology from current ones, thereby destroying the value of existing technical competencies (Linton, 2002). New innovative business models can also initiate disruption, which has wide impacts on industrial enterprises and the service sector; new market conditions emerging from this disruption may require significant adaptations in terms of new institutions and regulations (Kilkki et al., 2018). Significant disruptions affect entire industries and all of society.

Within industrial ecosystems, disruptive business models are driven by the emergence of data-driven economies as well as servitisation, i.e., offering operational excellence as a service (see introduction, Figure 2). As defined above, disruptive technology alone is not a synonym for disruptive transformation. Transformation requires a business model that links new technology to emerging market needs, i.e., disruption of current business and operation models, networks, capabilities and logic of actions. Especially disruptive transformation requires a well-grounded understanding of the wider ecosystem, which turns disruptive technologies to novel business models together with new partners, for new customers, while the playground is changing.

As discussed in the introduction, the dominance of hardware is diminishing as the new business environment emphasises services and software. One scenario is that these new players take over the industry and logistics data streams while offering the customers 'smart layer' machines and devices. In this scenario, the machine and

[31] http://www.bdva.eu/sites/default/files/BDVA_SMI_Discussion_Paper_Web_Version.pdf

equipment manufacturer's role remains supplying simple components to a heavily competitive market. The trend poses a challenge for traditional machinery manufacturers and suppliers, since digital service technologies require a vision of how the sector is developing and broad expertise in various sub-areas, such as IT and automation systems.

New operators

New operators, such as Uber,[32] may bring disruptive and effective models to control resources in industrial applications. Digital solutions may also give rise to end-to-end operators who will take over supply chains on the door-to-door or truck-to-truck basis. Examples of such entrants are the Elisa Smart Factory Management[33] (and Massterly in Norway[34]).

To survive and renew, an organisation needs to balance stability and change. Success in the global competition of industrial ecosystems requires a deep understanding of customer value, the ability to utilise technological developments in products and services and renewal of operations with digitalisation and other enabling – and sometimes disruptive – technologies.

In the data economy era, companies need to re-think the meaning of their assets, i.e., if their competitive edge is built on heavy assets and investments, they are not as agile as companies building their competitiveness on digital solutions and network effects enabled by their platforms. Thus, the transformation in asset intensive sectors is slower than in service sectors (Kortelainen et al., 2018).

Transform Finnish manufacturing beyond the Industry 4.0 era: Renewal Industry[35]

Factories are becoming innovation platforms where several actors can develop and try new things over network borders. **Reboot IoT Factory** is an example of a program boosting this change, and IoT solutions are at its core. Additionally, wireless networks, augmented reality, big data or even AI can provide significant added value in a factory setting, and bringing these technologies to factories in an agile fashion is very attractive for start-ups. The 'factory – IoT company mismatch' has been avoided when the risks and benefits of cooperation are in a good balance for all participants.

Potential benefits include:

- Independent view of work labour competence and work scheduling at factory level
- Edge computing, which allows real-time production control (e.g. material flow production)
- Human behavioural modelling (e.g. via camera allows on-site real-time programming of robot movements in case of a new product assembly or fault situation)
- Wirelessly controlled robots, allowing flexible production
- Digital twin of a product integrated with data from a product on the field allows business model change
- Predicting customer orders from business data, which allows predictive supply chain management (e.g. order parts before order)

IoT solutions may significantly transform energy markets in the future; already, the role of the consumer is changing to a producer of renewable energy (wind and solar). Energy companies are piloting solutions, enabling facilities' energy balance and the

[32] https://en.wikipedia.org/wiki/Uber
[33] https://elisa.com/iot/industrial-iot/
[34] www.km.kongsberg.com/
[35] Based on Marko Jurvansuu's blogpost. https://vttblog.com/2017/12/08/factories-are-becoming-innovation-platforms/

control of consumption locations as groups. Concurrently, exploiting different information of facilities changes cities' decision-making. New players are entering to the market and in the interconnected city environment, they need strong networks.

Smart Otaniemi as a test bed for future energy solutions[36]

Finland as a leading pilot base for flexible energy system. **An ecosystem** is a test bed for future energy solutions. Smart Otaniemi takes advantage of energy-related data, IoT applications, real-time controllability and flexible and distributed energy production.

Creating a smarter future together

SMART OTANIEMI

The Internet of Energy will transform future energy markets. Using a 5G network and IoT platform enables flexibility to empower customers to become prosumers. Smart Otaniemi links together electricity, heat and transportation with energy production and storage to make our energy use smarter and more efficient while reducing CO_2-emissions.

Conclusions and Recommendations

When foreseeing the future 'beyond IoT business' at the crossroads of technology and business disruptions, it is easier to foretell the importance of 5G, edge computing or data singularity than how the hyper-connected environment transforms industrial ecosystems or society. However, the speed of technological breakthroughs is significantly increasing, and their implementation is accelerating all the time. Thus, digital platforms will probably enhance the change towards seamless user experiences and role changes in current ecosystems. Disruptive change means that new entrants are offering lowering prices, meeting customer needs in novel ways and making better use of unutilised resources. For instance, autonomous trucks without drivers could dramatically change transportation operations, as the cost for the driver often represents 50–70% of the total cost for the truck (Sandberg & Hemilä, 2018). In addition, solutions are already ranging from people whose devices monitor health and wellness to manufacturers that utilise sensors to optimise equipment maintenance and protect workers.

Business based on data and services calls for a visionary approach to disruptions and future markets. Both incumbents and new players, as well as manufacturing and IT companies, have opportunities to become winners of the game. This requires companies to combine deep domain expertise with a thorough understanding of related digital technologies. In addition, the convergence of industrial sectors drives towards cross-border business models and networks, where new partners and collaboration models are needed.

With its growing significance as a key component of doing business, 'data' – or rather the knowledge that utilises data as raw material – should be regarded as an intellectual asset that delivers or has a potential to deliver value that can be monetised (Fleckenstein & Fellows, 2018). In this century, data may become the most important form of capital (Harari, 2018). Most IoT data within industrial ecosystems are not currently used. There are several reasons for this, data ownership being the most mentioned. Other aspects include data sovereignty, interoperability of IoT systems,

[36] www.smartotaniemi.fi

etc. In addition, it is good to understand that not all data have huge potential, and there might be some data that are only valuable once (e.g. when controlling one part of a process). New dynamic industrial ecosystems are already evolving around IoT solutions. A real impact can be gained by changing how goods are made and distributed, how products are serviced and refined and how resources are shared and circulated. Furthermore, the transformation requires investment in new capabilities and skills, i.e., learning and re-learning. This is especially true for organisations that have enjoyed great success, as the disruption means that some of their current capabilities and skills become outdated.

References

Ailisto, H., Mäntylä, M., Seppälä, T., Collin, J. & Halen, M., Juhanko, J., Jurvansuu, M., Koivisto, R., Kortelainen, H. & Simons, M., & Tuominen, A. & Uusitalo, T. (2015). Finland – The Silicon Valley of Industrial Internet. Governments' analysis, assessment and research activities.

Ailisto, H. (2018). Are we facing third AI winter, presentation at AI & Digital Business 2018, Kattilahalli, Helsinki 14.11.2018.

Business Finland, Liikenne- ja viestintäministeriö, Teknologiateollisuus ja Verkkoteollisuus .(2018). Digibarometri 2018. Helsinki: Taloustieto Oy. http://www.digibarometri.fi, http://www.digibarometri.fi/uploads/5/8/8/7/58877615/digibarometri_2018.pdf (pp. 10–20, in Finnish).

Big Data challenges in smart manufacturing. (2018). Discussion Paper on Big Data challenges for BDVA and EFFRA Research & Innovation roadmaps alignment. Version 1, 2018. http://www.bdva.eu/sites/default/files/BDVA_SMI_Discussion_Paper_Web_Version.pdf.

Botta, A., de Donato, W., Persico, V., Pescape, A. (2016). Integration of Cloud computing and Internet of Things: A survey. Future Generation Computer Systems, vol. 56, pp 684-700. https://doi.org/10.1016/j.future.2015.09.021

Gartner. (2012). Magic Quadrant for BI platforms. Analytics Value Escalator.

Fiegenbaum, A. & Thomas, H. (2004). Strategic risk and competitive advantage: an integrative perspective. European Management Review 1, 84–95.

Fleckenstein M. & Fellows, L. (2018). Modern Data strategy. Springer International Publishing AG.

Hanski, J. Ahonen, T. Uusitalo, T. Vainio, H. & Valkokari, P. (2018a). Smart asset management: stories from the world of digital services. Project deliverable 3.0. https://www.vtt.fi/sites/smartadvantage/publications.

Hanski, J. Kortelainen, H. & Uusitalo, T. (2018b). The impact of digitalization on product-service system development in the manufacturing industry. The 13th World Congerss on Engineering Asset Management (WCEAM 2018), Stavanger, Norway.

Harari, Y. (2018). 21 lessons for the 21st century. Spiegel & Grau, New York.

Iivari, M.M. Ahokangas, P. Komi, M. Tihinen, M. & Valtanen, K. (2016). Toward Ecosystemic Business Models in the context of Industrial Internet. Journal of Business Models 4(2).

Juhanko, J., Jurvansuu, M., Ahlqvist, T., Ailisto, H., Alahuhta, P., Collin, J., Halen, M., Heikkilä, T., Kortelainen, H., Mäntylä, M., Seppälä, T., Sallinen, M., Simons, M. & Tuominen, A. (2015). Suomalainen teollinen internet – haasteesta mahdollisuudeksi: taustoittava kooste. ETLA Reports No 42. http://pub.etla.fi/ETLA-Raportit-Reports-42. pdf

Kane, G., Palmer, D., Phillips, A., Kiron, D. & Buckley, N. (2015). Strategy, not Technology, Drives Digital Transformation. MIT Sloan Management Review and Deloitte University Press, July 2015.

Karhula, P., Makela, J., Rivas, H. & Valta, M. (2017). Internet of Things connectivity with gateway functionality virtualization. Global Internet of Things Summit, GIoTS 2017.

Kilkki, K., Mäntylä, M., Karhu, K., Hämmäinen, H. & Ailisto, H. (2018). A Disruption Framework. Technological Forecasting and Social Change 129, 275–284.

Kortelainen, H., Uusitalo, T., Hanski, J., Bäck, A. & Bergman, J-P. (2018). Näkökulmia digitalisaation myönteisiin vaikutuksiin – Delfoi-tutkimus. Talous ja yhteiskunta (in publication process).

Kortelainen, H., Hanski, J., Kunttu, S., Kinnunen, S.-K. & Marttonen-Arola, S. (2017). Fleet service creation in business ecosystems – from data to decisions. VTT Technology 309. 70 p. + app. 6 p.

Millar, C., Lockett, M. & Ladd, T. (2018). Disruption: Technology, Innovation and Society. Technological Forecasting and Social Change 129, 254–260.

Lee, I. & Lee, K. (2015). The Internet of Things (IoT): Applications, investments and challenges for enterprises. Business Horizons 58, p 431–440. Elsevier.

Lee, J.. Bagheri, B. & Kao, H-A. (2015). A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems. Manufacturing Letters 3, 18–23.

Leveson, N.G. (2011). Engineering a safer world. System thinking applied to safety. Cambridge: The MIT Press.

Linton, J.D. (2002). Forecasting the market diffusion of disruptive and discontinuous innovation. IEEE Trans. Eng. Manag. 49, 365–374.

Nicolescu, R. Huth, M. Radanliev, P. & De Roure, D. (2018). State of the Art in IoT– Beyond Economic Value. White paper. https://iotuk.org.uk/wp-content/uploads/2018/08/State-of-the-Art-in-IoT-%E2%80%93-Beyond-Economic-Value2.pdf.

Parviainen, P., Tihinen, M., Kääriäinen, J. & Teppola, S. (2017). Tackling the digitalization challenge: how to benefit from digitalization in practice. International journal of information systems and project management 5(1), 63–77.

Sandberg, E., & Hemilä, J. (2018). Digitalization in Industrial Logistics and Supply Chains – The Contemporary Situation in Sweden and Finland, The Proceedings of 23rd International Symposium on Logistics, ISL 2018 – Big Data Enabled Supply Chain Innovations, 8th – 11th July 2018, Bali, Indonesia.

Tiusanen, R. (2014). An approach for the assessment of safety risks in automated mobile work-machine systems. VTT Science 69. Espoo.

Valkokari, Valkokari, K., Rantala, T., Alamäki, A. and Palomäki, K. (2018) ”Business impacts of technology disruption – a design science approach to cognitive systems' adoption within collaborative networks”, The proceedings of the 19th IFIP/SOCOLNET Working Conference on Virtual Enterprises, Pro-Ve 2018, 17-19 September, Cardiff, UK.

Authors

Helena Kortelainen

Leila Saari

Katri Valkokari

Maija Federley

Juhani Heilala

Jyrki Huusko

Esa Viljamaa

Workshop Participants:

Heikki Ailisto	Toni Ahonen	Maria Antikainen
Maija Federley	Jukka Hemilä	Marko Jurvansuu
Ari Jussila	Hannu Karvonen	Kai Katajamäki
Helena Kortelainen	Ville Kotovirta	Juhani Latvakoski
Jutta Nyblom	Jari Rehu	Leila Saari
Magnus Simons	Juha-Pekka Soininen	Kaisa Still
Markus Taumberger	Teuvo Uusitalo	Katri Valkokari
Matias Vierimaa	Esa Viljamaa	Juhani Heilala

For more information please contact

Leila Saari
Tel. +358 40 8208929
leila.saari@vtt.fi

Helena Kortelainen
Tel. +358 40 7262977
helena.kortelainen@vtt.fi

Katri Valkokari
Tel. +358 40 8479352
katri.valkokari@vtt.fi

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