Alliance for Internet of Things Innovation

White Paper: Business Impact of IoT in Manufacturing Industries

Release 1.0

AIOTI WG Smart Manufacturing

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Introduction

Typically, in the research and innovation AIOTI community (e.g. H2020 and now Horizon Europe Programme - HEP), industrial IoT solutions are developed, deployed and discussed in detail, but it is very challenging to provide potential users with convincing business cases, to take up such technical solutions in practice in their daily business. In this respect, it is important, in addition to the deep technical discussions and elaborations, to also work out what benefits a manufacturing enterprise (SME) can get from an industrial IoT solution.

For this purpose, the AIOTI WG Manufacturing held a workshop on 8 February 2022, on "Business impact of IoT in manufacturing industries". In this workshop concrete multi-stakeholder business cases were presented, which had been prepared according to a common methodology, to illustrate not just the benefits derived from the adoption of Industrial IoT Platforms, but also the required changes in the Business Models of each stakeholder, in order to maximise such benefits. The presented business scenarios were complemented by further examples after the workshop.

This white paper aims to describe all these business scenarios according to a common methodology (namely Business Model Navigator) in order to identify commonalities / differentiating aspects and support a comparative benchmarking analysis. The white paper claims that the preparation of the individual cases is generally understandable for people who are familiar with the fundamental value creation processes in manufacturing industries. The white paper should also illustrate the various ways IoT in manufacturing industries can impact the design of business models. Feedback to this elaboration is highly welcome.

Methodology: the multi-stakeholder Business Model Navigator

In the context of a platform economy Industrial IoT business case it is typically not enough to consider a single provider-customer relationship but an overall value network. In this value network a convincing value proposition for all participants should be developed, even if this implies some changes in the current business models of the stakeholders. This conceptual approach is aligned with the methodology proposed by the working group "Digital Business Models" of Plattform Industrie 4.0 to analyse practical examples, see [1].

Thus, the starting point for the analysis and documentation of a business scenario is the description of a value network. An example of a value network is illustrated in *Figure 1*.

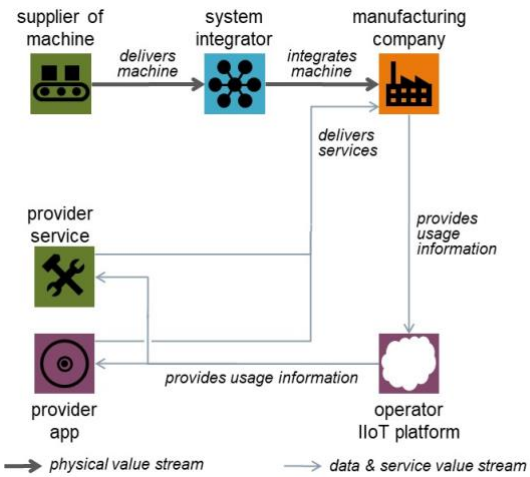


Figure 1: Description of value networks (illustration)

A value network is a directional graph consisting of nodes and edges. The nodes of the graph are business stakeholders and the edges of the graph are business relationships. Each node represents a business role and comprises a description of the underlying business model. Each edge represents a value proposition of a provider to a customer.

The individual business roles in a value network are assumed by enterprises. This is indicated by colouring the business roles, whereby each enterprise is represented by a specific colour. An enterprise may assume several business roles, thus, business roles coded by the *same colour* are assumed by a *single* enterprise. Business roles coloured in white represent different enterprises assuming exactly one business role but will not be considered in more detail in the description, because these business roles do not contribute to the core of the example.

The value network is complemented by a description of the business model of each enterprise. The description uses the St. Gallen Business Model Navigator method, see [2]. This method is based on a magic triangle with 4 dimensions, see *Figure 2*:

- Who (customer): What are the target customers of the enterprise?
- What (value proposition): What is the offering of the enterprise to the customer?
- How (value chain): How does the enterprise produce the deliverable?
- Value (revenue mechanism): How does the enterprise creates revenues?

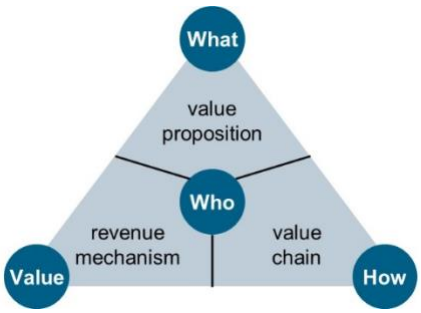


Figure 2: St. Gallen Business Model Navigator

To distinguish business model innovations from product or process innovations at least two dimensions should be involved in a significant way. "Significant" means that the considered dimension is addressed structurally in a different way. Examples for significant changes are addressing a new market segment, integrating a new business partner in the value chain or a recurring usage-based payment instead of a one-time payment. The assessment whether a change is significant is to a certain degree a subjective assessment.

Figure 3 illustrates how the analysis of business model innovation can be integrated into the illustration of the value streams.

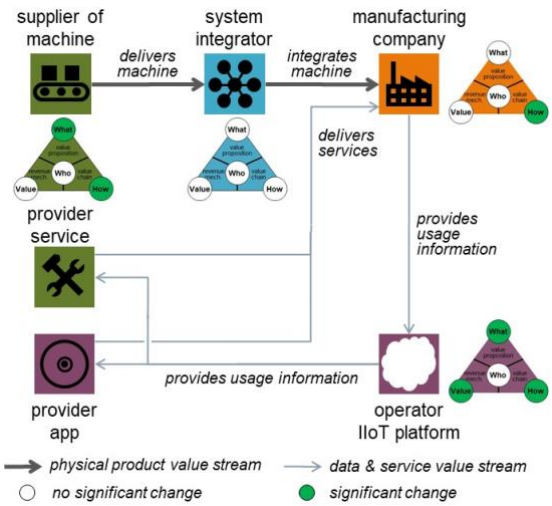
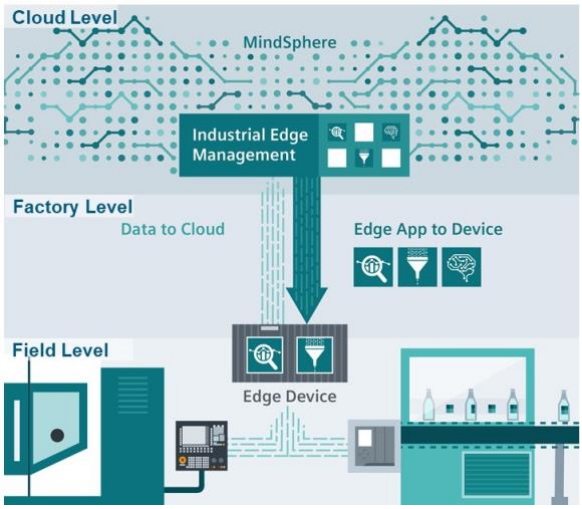


Figure 4: Business model innovation of enterprises involved in the value network (illustration)

Examples

1. Siemens Industrial Edge – Infrastructure to intelligently exploit own data

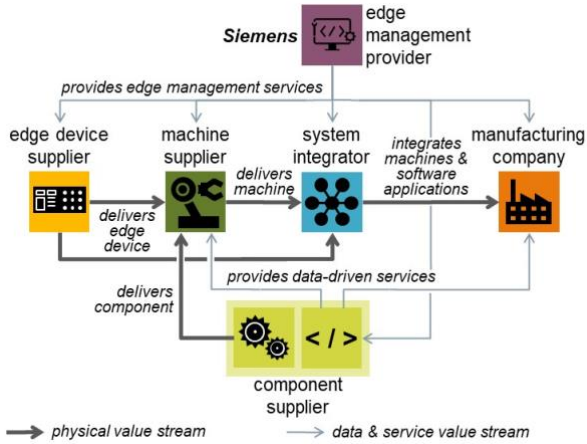
Overview



Many manufacturing companies are challenged by exploiting the full potential of their machine and plant data to increase competitive edge and generate new business models. To address these challenges Siemens offers Industrial Edge, which comprises a central infrastructure to manage edge devices and industrial edge applications. Industrial edge applications for intelligent data use can be provided by any company and can be deployed on edge devices providing secure, future-proof basis for running industrial edge applications. Based on Industrial Edge local, decentralized, and fast data processing can be achieved, the storage and transmission costs for data can be reduced and all this with full control over the own data.

The application of Industrial Edge is explained using the example of a component supplier, who wants to offer data-driven services. Technically, the service is realized by an edge application, but the component supplier does not want to integrate an edge device into its component. By using Industrial Edge the edge application can be centrally managed and deployed on any edge device supported by the Industrial Edge. Such an edge device can be part of a machine or the overall plant.

Value Network



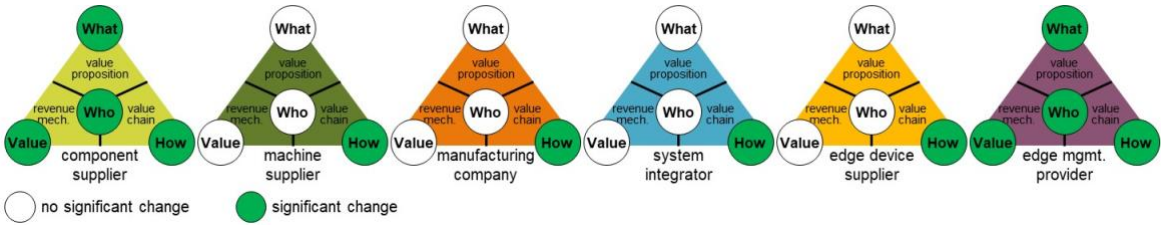
The value network shows the classic value chain, in which components are integrated into machines and these are integrated by system integrators into a plant of a manufacturing company. The edge devices on which the component supplier would like to deploy its edge application can be integrated into the machine by the machine supplier or into the plant by the system integrator. The component supplier offers the data-driven service to the machine supplier or the manufacturing company.

As an edge management provider, Siemens offers partners in the value chain various edge management services, for example services to edge device supplier to make its edge devices accessible to edge management; services to machine supplier and system integrator to integrate and manage edge devices and to deploy edge applications on the edge devices; services to the component supplier to make own edge application available to the machine supplier, system integrator or the manufacturing company; and services to the manufacturing company to be able to deploy edge applications on edge devices of the plant.

Typically, the various stakeholders in the value network charge for the purchase of their components and the use of their services. The component supplier may compensate the machine supplier or the manufacturing company for the use of the provided edge device.

Business Model Innovation

The business model changes of the companies considered in this example can be summarized as follows:

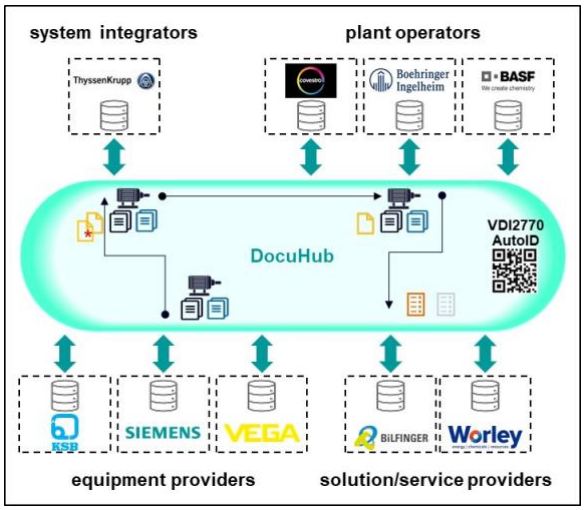


The edge management provider is establishing itself as a new partner in the value network. Thus, all four dimensions change significantly for the edge management provider. Because of the integration of the edge management provider also the value chain for the other partners changes in a significant way.

In addition to the value chain, the other three dimensions of the component supplier are also changing significantly: the customer, because the manufacturing company is addressed as a new customer segment, the value proposition, because new data-driven services are offered, and the revenue mechanism, because, in contrast to the one-time payment for components, data-driven services are billed usage or even outcome based.

2. Siemens DocuHub – Keeping technical documentation of equipment up to date

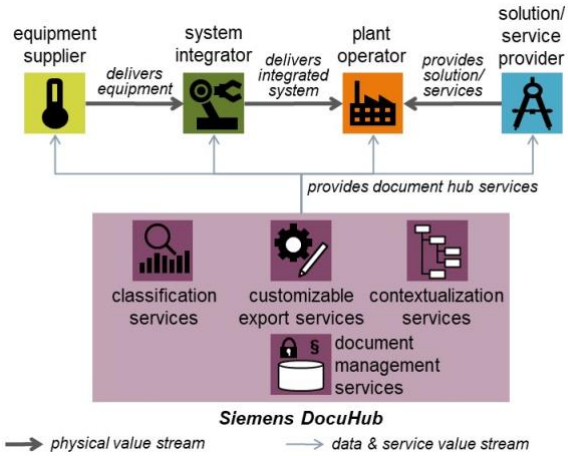
Overview



Today, document handling drives operational expenditure and risks during operation of complex equipment. Documents are exchanged in many technical ways based on highly manual, specific, and thereby costly workflows. Often there are more than 10,000 equipment per plant and more than 20 documents per equipment. Therefore, today equipment information often is not available when needed, for example 80% of maintenance time is needed to find the correct information.

To address these challenges Siemens provides DocuHub, a shared system offering services to assign metadata to documents and to legally exchange documents between equipment provider and equipment operator. Using these services an equipment operator has up to date and consistent documentation of equipment and an equipment provider can make the documentation for an equipment available in an easy way. In addition, an equipment provider can offer additional documentation related services over the lifecycle of the delivered equipment, for example notification services regarding updated documents.

Value Network



The value network shows the classic value chain, in which equipment is integrated by system integrators – for example a machine supplier – and the integrated system is delivered to a plant operator. In addition, the plant operator uses the services – for example engineering or maintenance services – of solution/service provider.

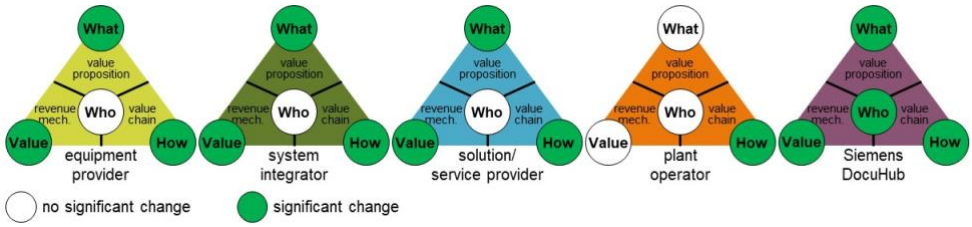
All these partners act in the role of document providers. For example, the equipment provider and system integrator provide documents about the equipment or integrated system, the solution/service provider documents about the services provided and the plant operator documents about the operation of its plant. Assuming the role of document providers they can use specific Siemens DocuHub services.

System integrators, solution/service providers and plant operators also act in the role of document consumers. For example, a system integrator receives documents from an equipment provider, a plant operator receives documents from a system integrator or solution/services provider and a solution/service provider can receive documents from all other partners in the value network. Assuming the role of document consumers they use further Siemens DocuHub services.

Typically, the various stakeholders in the value network charge for the purchase of their equipment, systems, solutions, and services and for the used services of Siemens DocuHub.

Business Model Innovation

The business model changes of the companies considered in this example can be summarized as follows:

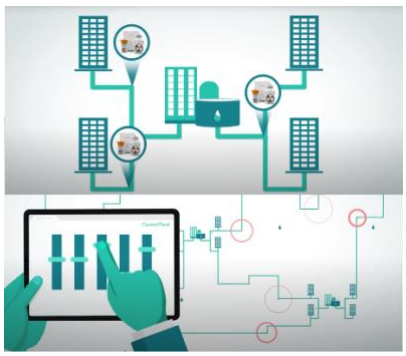


Siemens DocuHub is establishing itself as a new stakeholder in the value network. Thus, all four dimensions change significantly for Siemens DocuHub. Because of the integration of Siemens DocuHub also the value chain for the other partners changes in a significant way.

In addition to the value chain, for the equipment provider, system integrator and solution/service provider also the value proposition and revenue mechanism change significantly, because they can offer additional document related services to their customers based on Siemens DocuHub and in contrast to the one-time payment for equipment, system integration, or solution, the additional document related services are billed usage based.

3. Aqua Robur – Secure Water Resources and Monitor Water

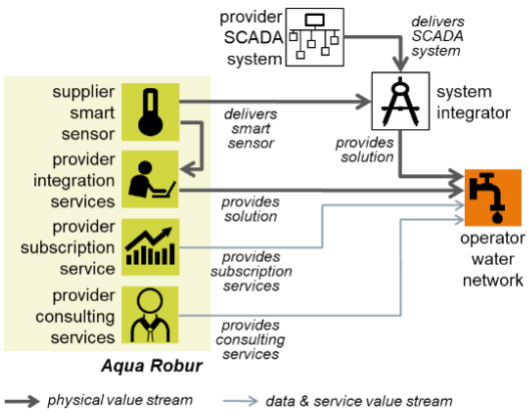
Overview



Today, a leakage level of around 20-25% in public fresh-water pipelines leads to an enormous loss of water and thus to costs of billions of euros in Europe. Since water pipelines are underground and mostly laid over thousands of kilometers in unpopulated areas, monitoring of the network is very difficult and costly. Initial solutions to detect leakages through the use of sensors that provide smart and wireless metering leads to the challenge of providing external power supply and signal amplification, which requires battery changes or costly grid connections.

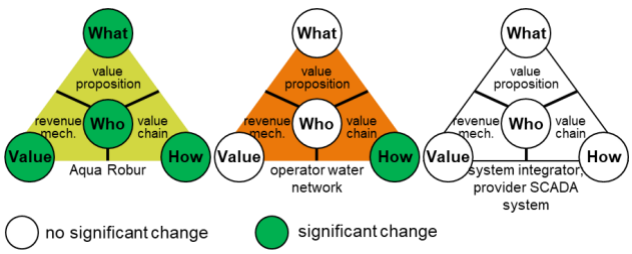
To address these challenges, Aqua Robur Technologies is developing and manufacturing smart and wireless measurement systems that helps water utilities to control their water networks. Aqua Robur uses a micro-hydro-system that converts water flow into power supply to generate a stable power supply for the sensors that monitor the pipelines. A sensor node can be placed at strategic positions in the network and collects and transmits recorded sensor data. This plug-and-play IoT solution with integrated software enables the monitoring and management of whole water networks.

Value network



In the value network, Aqua Robur offers several services and product solutions. Either Aqua Robur provides its smart sensors to a system integrator who integrates the sensors into the SCADA system of a water network operator, or Aqua Robur offers the smart sensors including its integration services as a complete solution. In addition, Aqua Robur provides the operator with its own access environment where the recorded data can be easily retrieved and combined with external information (e.g. weather data). The water network operator is enabled to optimize its monitoring and management by the consulting service offered by Aqua Robur. The SCADA system provider assumes the role of a software supplier and the system integrator the role of a contracted service provider.

Business model innovation



Aqua Robur is establishing itself as a new player in the value network. By starting as a new company, Aqua Robur offers a new product with additional new services, which significantly change all four dimensions. In addition, the value creation process of the water network operator is improved and significantly changed by using the monitoring service. Nevertheless, the operator delivers the same value to the same customers as before. The business models of the system integrator and the provider of the SCADA system do not change, and they remain as contracted software and service supplier.

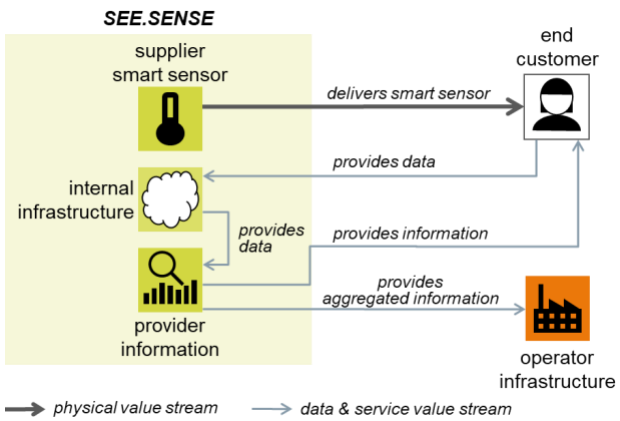
4. See.Sense – Reactive Bike Lights by sensor technology

Overview

Cyclists in cities have the great danger of not being noticed in road traffic. Due to poorly developed bicycle road networks as well as unclear intersections and bad road conditions, cyclists are involved in many accidents and collisions every day. Intensive lighting for cyclists is crucial, especially at particularly critical points. However, a permanent high intensive lighting consumes very much energy and would discharge the battery very quickly.

To address these challenges, See.Sense developed a sensor technology that is integrated in bike lights and monitors the environment (up to 800 times per second) for dangerous situations. If a risky environment is detected, the bike lights become more intensive and indicates the cyclist by clear signals. Through additional sensors, such as accelerometer or GPS, various data is collected during the ride (i.e. cycle positioning, road surface quality, …). By connecting the bike light to a smartphone, the data can be analyzed for further insights. If the cyclist allows data sharing, the route information and collected data are transmitted to See.Sense, which can analyze the aggregated data and identify factors for road problems and poor route conditions. By sharing the anonymous data with planners and engineers, urban planning and signage can be improved to make cycling more attractive and safer.

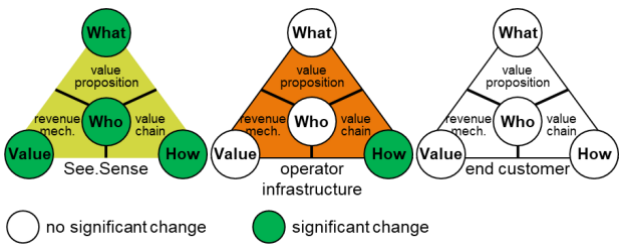
Value network



The value network includes the typical sale of a product, in this case of a bike lighting with smart sensor from See.Sense to an end customer. If end customers connect their smartphones and transmit their sensor data, See.Sense provides insights for the end customer including statistics on riding characteristics and route progress.

In case the cyclist agrees to a further anonymized data transfer, the value creation network expands. In this case, road planners as well as city planners can receive sensor data from See.Sense based on the internally evaluated data and thus influence the improvement of their planning activities. By sharing their sensor data, end users benefit through an improved traffic planning for cyclists on a long term. See.Sense acts as a facilitator of this data and provides value by enabling an overall improvement for users and operator of infrastructure.

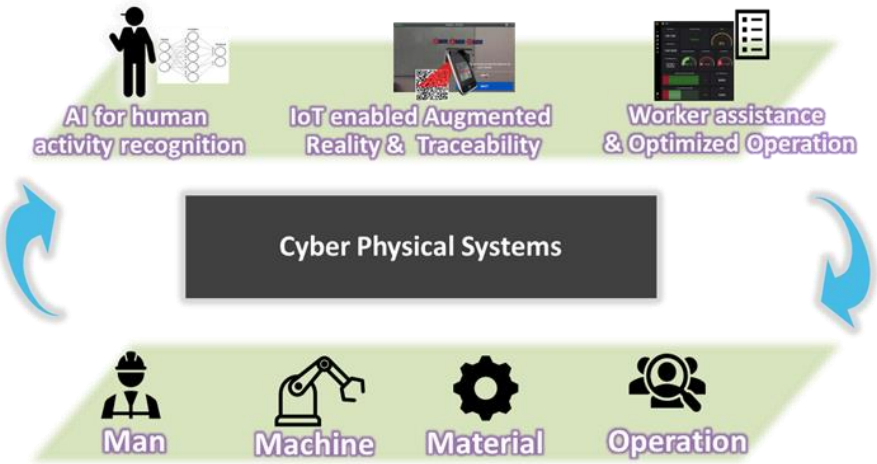
Business model innovation



See.Sense is establishing itself as a new player in the value network. By starting as a new company and providing a new offering, all four dimensions change significantly. Furthermore, the infrastructure operator's processes significantly change, because roads, cycle paths or entire cities can now be planned based on sensor data from cyclists. However, the value proposition and the customers of the infrastructure operator remain the same. Even though the end customer is not a business actor with a real business model, the elements of business model innovation do not change for this role.

5. Hitachi – Maintenance assistance and predictive maintenance

Overview

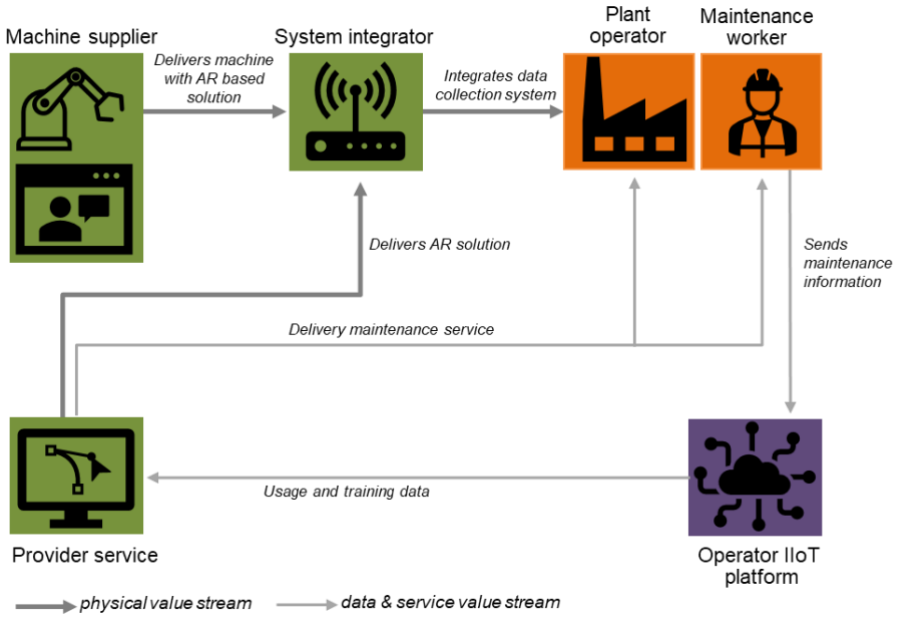


The increasing use of new technologies in industries is improving efficiency, but also creating challenges to maintenance workers. Maintenance workers need to continuously learn and adapt to a greater variety of machines, increasing the complexity of their activities. Knowledge transfer needs will become increasingly important in aging society.

Hitachi presents a solution for training and assisting maintenance workers, by implementing a IoT-based system which process 4M data (huMan, Machine, Material, Method). The system tracks maintenance activities of assets and starts visually guided maintenance support via IoT-based AR applications. The solution digitalizes the machine maintenance steps. The AR application integrates capabilities to check the machine ID and the material ID (e.g., verify tools and spart parts before replacing), to display machine status (e.g., temperature and pressure), and to validate and record worker's actions and display the step-by-step information to perform the maintenance tasks. The solution uses in parallel wearable sensors in the maintenance worker to confirm the execution of the listed maintenance tasks, by using Hitachi's AI-based human activity recognition technology (DFKI and Hitachi Jointly Develop AI Technology for Human Activity Recognition of Workers Using Wearable Devices | Hitachi in Europe). The system guides the worker while collecting a digital maintenance log with the activities executed in the asset. An IoT device with edge-AI capability is used to process the asset and machine sensor data, to execute human activity recognition technologies, and to synchronize with IoT-based AR applications.

After each maintenance intervention, the solution transmits a digital maintenance log with the tasks executed in each asset. The detailed monitoring of the maintenance intervention enables the application layer of the solution: Predictive Maintenance, Data Analysis & KPI monitoring, and Maintenance Optimisation.

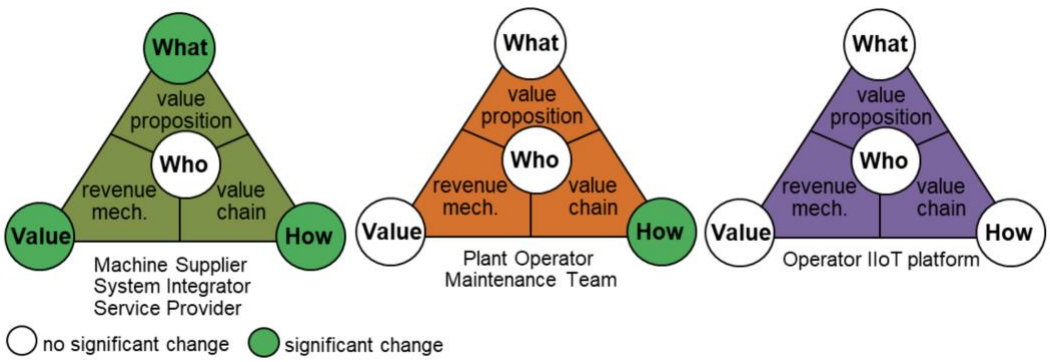
Value Network



The value chain provides added value IoT services to expand Hitachi's industrial products business and integrate the services into IIoT platform as part of Hitachi's Digital Transformation Business. Hitachi's AI-edge device collects, process and sends the 4M data. The Last Mile Maintenance & Repair solution comprises the data collection, data management and data processing, including the functions at the perception layer of informing the worker about the maintenance tasks to follow, and the functions at the application layer of performing predictive maintenance, providing data analysis, and maintenance task optimization results. In the value network, the plant operator receives the value proposition of reducing his expenditure for the maintenance of the machines and thus operating more profitably.

Business Model Innovation

The business model changes for each of the actors involved in the value chain, it can be summarized as follows:



Hitachi, as machine supplier, may reduce the maintenance and warranty cost when the Maintenance & Repair solution is integrated as part of the machine delivery value chain. By leveraging Hitachi IT business (system integrator provider and service provider), Hitachi may also provide added value services to their customer such as Predictive Maintenance and Optimized Scheduling service, increasing its revenue streams. The functions of Machine Supplier, System Integrator and Service Provider and performed by different Hitachi divisions. Hitachi has IT and OT capabilities, and the combination of both areas of expertise allows the maximization of those capabilities, providing value and change in all four dimensions.

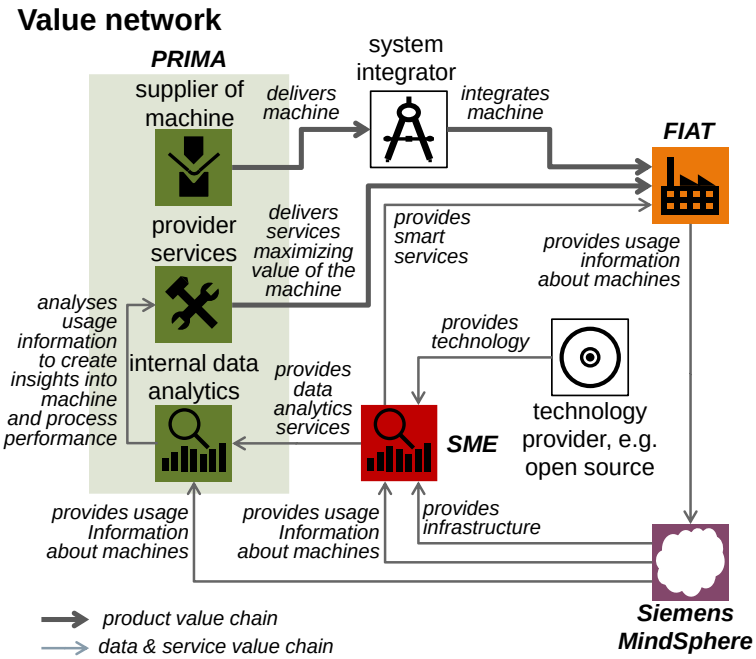
For the manufacturing company the solution targets the maintenance team. It answers the question of *who* should perform the maintenance tasks, when it has to be done, and *how* maintenance needs to be delivered. It also changes their current maintenance operation to a more collaborative scheme in which maintenance data is shared to the machine supplier for the supplier to provide machine value proposition services.

6. BOOST 4.0: Predictive Maintenance in FIAT Campus Melfi plant

Overview

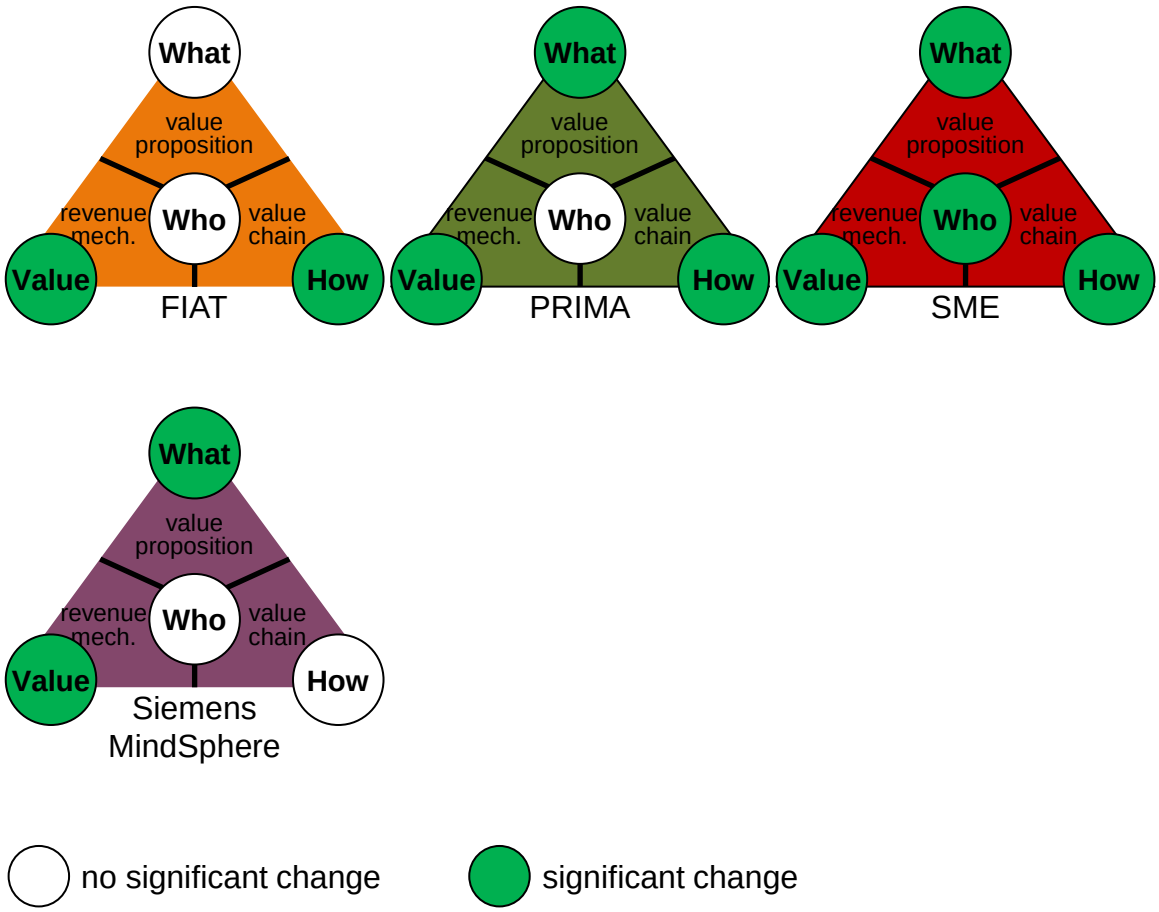
The welding cell of FIAT Melfi Campus plant is equipped with a PRIMA POWER Laser Machine Platino Fiber 1530, enriched with several additional sensors for health status monitoring and maintenance. Moreover, AGVs fleets provide in real-time huge quantities of data regarding their status, power consumption, wear-out, mission status. Thanks to FIWARE Open Source Industrial IoT framework data from the shopfloor is pre-processed and filtered at the edge and then submitted to the Siemens Mindsphere industrial cloud for further elaborations. In particular, an Innovation SME is in charge to access both PRIMA and FIAT tenants in Mindsphere and to elaborate an advanced Predictive Maintenance solution integrating needs from the PRIMA machine and from the FIAT AGV fleet.

Value Network



Four main stakeholders are included in this example: the Machine Supplier (PRIMA), the Plant Owner (FIAT), the Cloud Infrastructure Provider (SIEMENS) and the Advanced Application Developer (SME). PRIMA monitors the delivered machines (in a fleet management system where all the Laser Machines of the same typology are monitored and diagnosed) by using edge to cloud industrial IOT platform and services and delivers maintenance services. FIAT monitors AGVs and the status of the whole plant through its SCADA and ERP systems. SIEMENS provides the loud data infrastructure, respecting security and data confidentiality constraints. The SME is allowed to access both PRIMA and FIAT Tenants and develop advanced preventive maintenance plans, harmonizing the needs of both PRIMA and FIAT and exploiting the cloud infrastructure of SIEMENS (Mindsapp). This is a brand new business model for SMEs ecosystems which is enabled by the presence of an open edge-to-cloud infrastructure and by a digitally enabled value network.

Business model innovation



The four stakeholders in the FIAT Melfi Predictive Maintenance scenario need to harmonise and coordinate their Business Models in order to implement the scenario. SIEMENS and its cloud platform IoT is implementing its own business models. This is a very disruptive business model for SIEMENS, especially in the new value proposition and revenue mechanisms. FIAT needs to modify its revenue mechanisms (including Data Provision and Data Economy) and value chains, by adding new stakeholders. PRIMA mostly focusses on its value proposition, by implementing a transition between pure product-driven business to a more dynamic product-service business model (Servitisation). This has a very relevant impact on revenue mechanisms and establishes new relations in the value chain. The totally new actor in this value network is the SME who has to totally re-new its business especially in consideration to the SIEMENS Mindsphere and its MIndsapp ecosystem

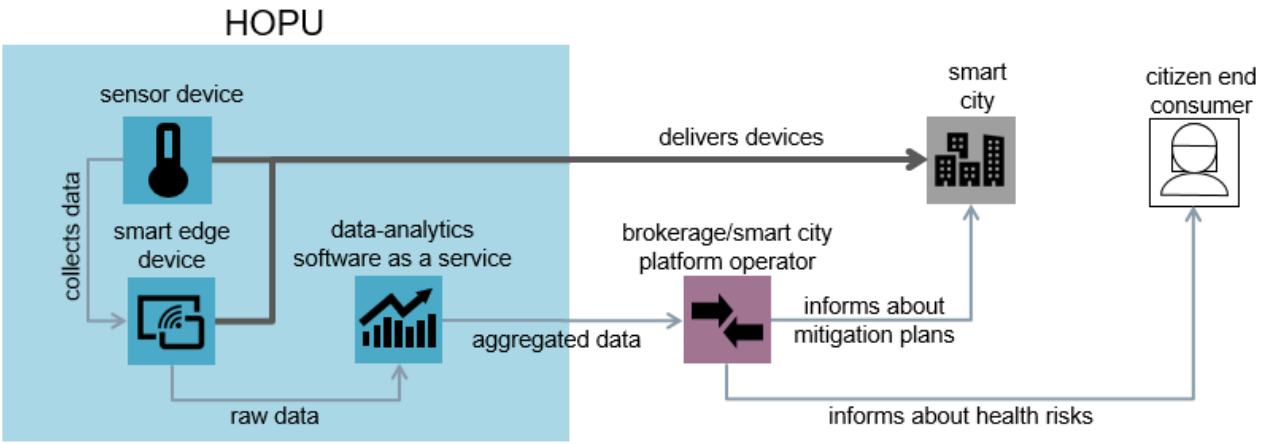
7. HOP Ubiquitous – Smart city development through environmental monitoring

Overview

Climate change and its negative impact on the health of humanity and our planet is an accelerating global concern. Cities are severely contributing to the concern, due to urban activities (primarily transport and buildings) being major sources of greenhouse gas emissions, and estimates suggest that cities are responsible for 75 percent of global CO2 emissions. However, cities find it difficult to navigate and select the most cost efficient and sustainable mitigation actions, posing a severe need for making urban design more agile to sustain the environment and quality of life of the citizens.

To address these challenges, HOP Ubiquitous (HOPU) is developing smart data-driven systems that help cities mitigate climate change. HOPU uses a system that consist of a sensing device to monitor up to 35 different environmental parameters, and an edge computing device to process the data in order to detect environmental anomalies and irregularities, and communicate the information to third-parties for supporting decision making processes and action planning. This solution enables cities to 1) monitor levels of environmental parameters that put citizens' health at risk, and 2) contextualize the data to identify optimal mitigation actions for achieving the ideal climatic quality that ensures the health of inhabitants, and to predict possible events that may put it at risk.

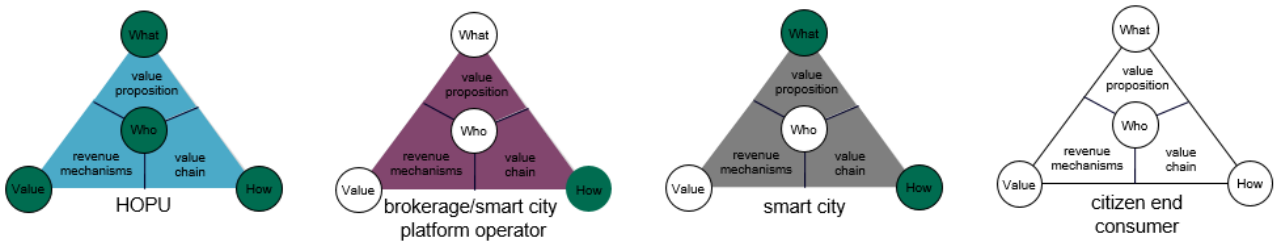
Value Network



In the value network, HOPU offers the smart data-driven monitoring system including its integrated services (data analysis, decision support and action recommendation) as a complete solution to (smart) cities. The sensor devices and smart edge devices are provided as physical objects to be installed in the city. The data generated on 35 environmental parameters by the sensors can be directly used by citizens in the form of warnings or services related to their health, but most likely will be offered via third-party data brokers (for example governmental departments with responsibility for the city sustainability, infrastructure, tourism etc.) The data broker receives aggregate data from HOPU, and process that data in view of their respective area of city responsibility, providing overall analysis to the city in the form of mitigation plans as well as to citizens in the form of applications.

Business Model Innovation

The business model changes of the enterprises considered in the value network example of HOPU can be summarized as follows:



HOPU is establishing itself as a new stakeholder in the value network, and thus, all four business model dimensions change significantly for the company. Due to the integration of HOPU into the network, also dimensions of the established partners' business models are subject for significant change.

The value chain of the brokerage that operates the smart city platform, as well as the value chain of the smart city that uses the platform, is improved and significantly changed by the provided monitoring and decision-making service. Also the value proposition of the smart city is significantly changed, as the city management is able to perform better environmental planning and climate mitigation actions. Nevertheless, the same value is being captured, and the same customers are being served as before.

A business model for citizens and consumers is not applicable. These are instead human beings that are impacted by the data insights and analytics provided by HOPU and the brokerage/smart city platform, as they are being informed about environmental and human health risks, which eventually changes value proposition.

8. ASTI Mobile Robotics - automation of industrial intralogistics

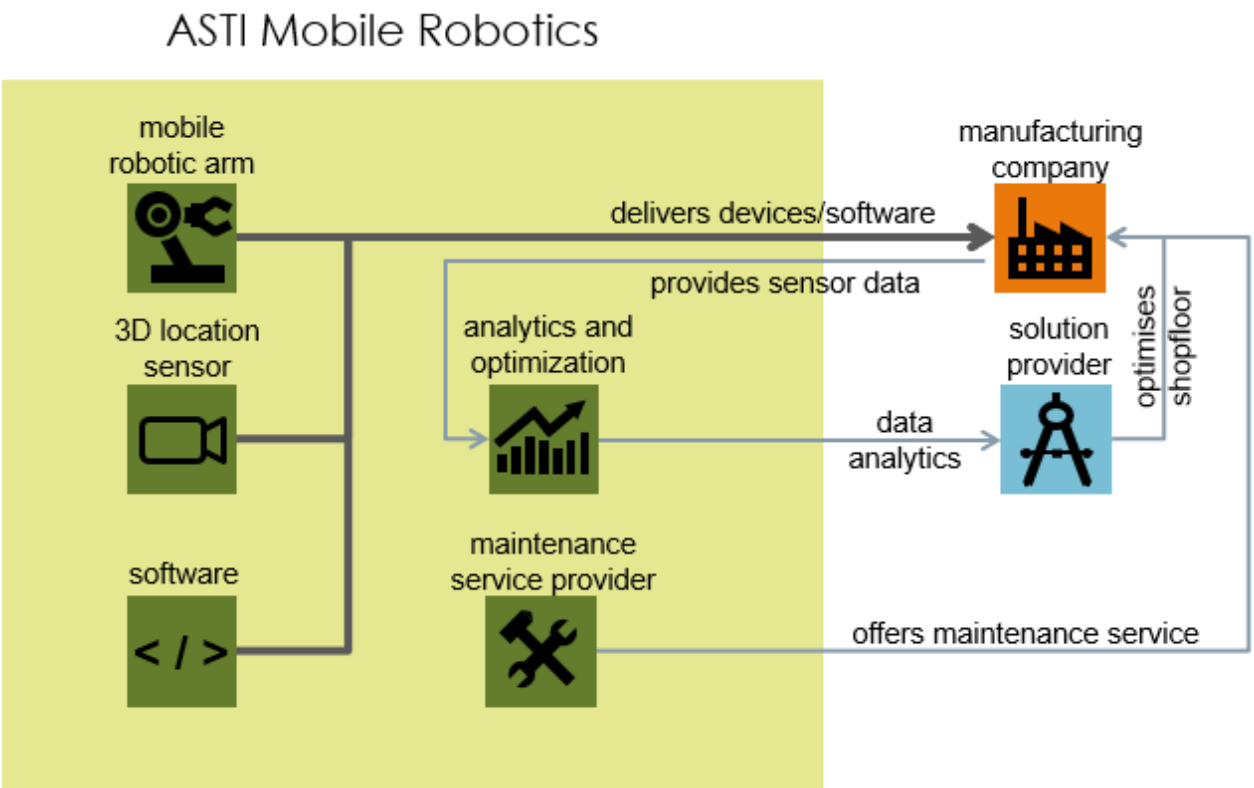
Overview

In recent years, the Internet of Things has radically transformed industries and how they have previously been operating, communicating, and utilizing data. Looking towards the future, automation is expected to accelerate and develop into a prerequisite operational efficiency in industrial environments. However, traditional manufacturers are lacking specific solutions to ease internal operational tasks and technological expertise to facilitate this transition.

To address these challenges, ASTI offers solutions that cover the intralogistics needs of todays connected industry. The intralogistics system is based on Automated Guided Vehicles (AGVs) and mobile robotics – put simply, an AGV and a robotic arm that are built together to collaborate and take over some of the manual tasks, which are repetitious and often cumbersome, from plant workers. A 3D sensor is mounted in the robot to perceive its relative position, and ultimately enable it to automatically perform a range of operational tasks. The software system of the robot supports bidirectional communication with all plant elements, and customer management systems, enabling monitoring of data points for operational optimization and decision making.

ASTI covers the entire value chain from system analysis, design, manufacturing, deployment, and maintenance. The intralogistics systems are used by industrial companies to move materials and products from one location to another within plants, helping to increase productivity and optimize competitiveness, flexibility, and time to market of manufacturing companies.

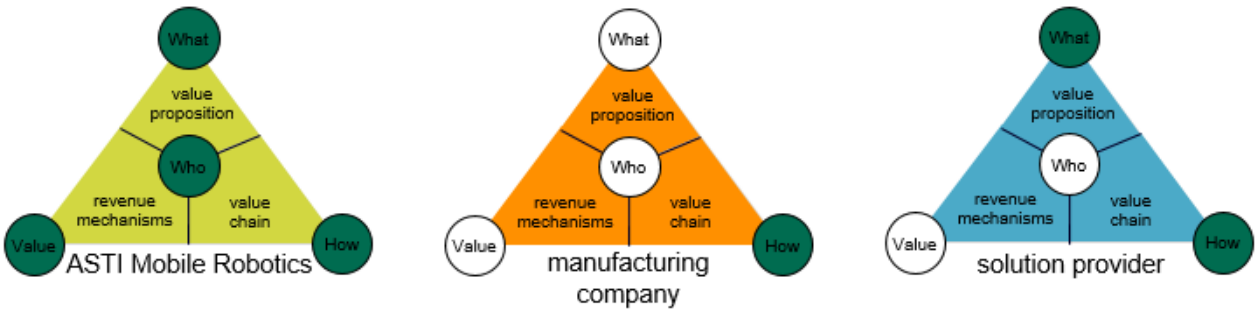
Value Network



In the value network, ASTI offers the intralogistics system as a complete process automation solution to manufacturing companies. The mobile robotic arm, sensor system and software are delivered as physical products to the manufacturing company, whereas information services allowing for shop floor analytics and optimization are offered via a solution provider to the manufacturing company. ASTI Mobile Robotics instead focusses on the full lifecycle of its own solution by offering maintenance services to the customer.

Business Model Innovation

The business model changes of the enterprises considered in the value network example of ASTI can be summarized as follows:

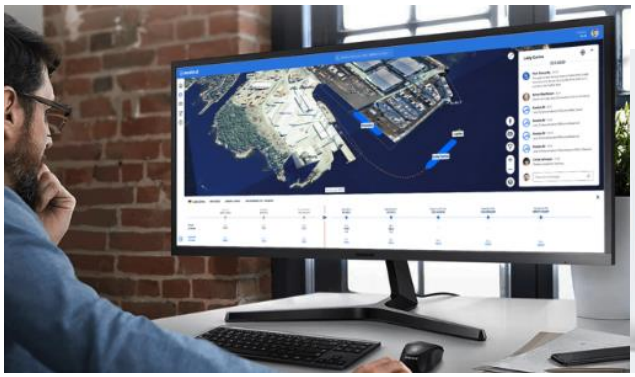


ASTI is establishing itself as a new stakeholder in the value network, and thus, all four business model dimensions change significantly for the company. Due to the integration of ASTI into the network, also dimensions of the established partners' business models are subject for significant change.

The value chain of the manufacturing company and the solution provider is enriched and significantly changed by using the intralogistics system in their own value creation process. Also the value proposition is significantly changed for the solution provider, as the data analytics provided by ASTI enables them to provide their service offering more efficiently and in greater quality. Both for the manufacturing company and the solution provider the same customers are being served and the same value is being captured, however, a great amount of unmeasurable internal value is being generated due to the internal process automation and shop floor optimization within the manufacturing company.

9. Awake.AI - Digitalising sea-port-land operations for intelligent maritime logistics

Overview

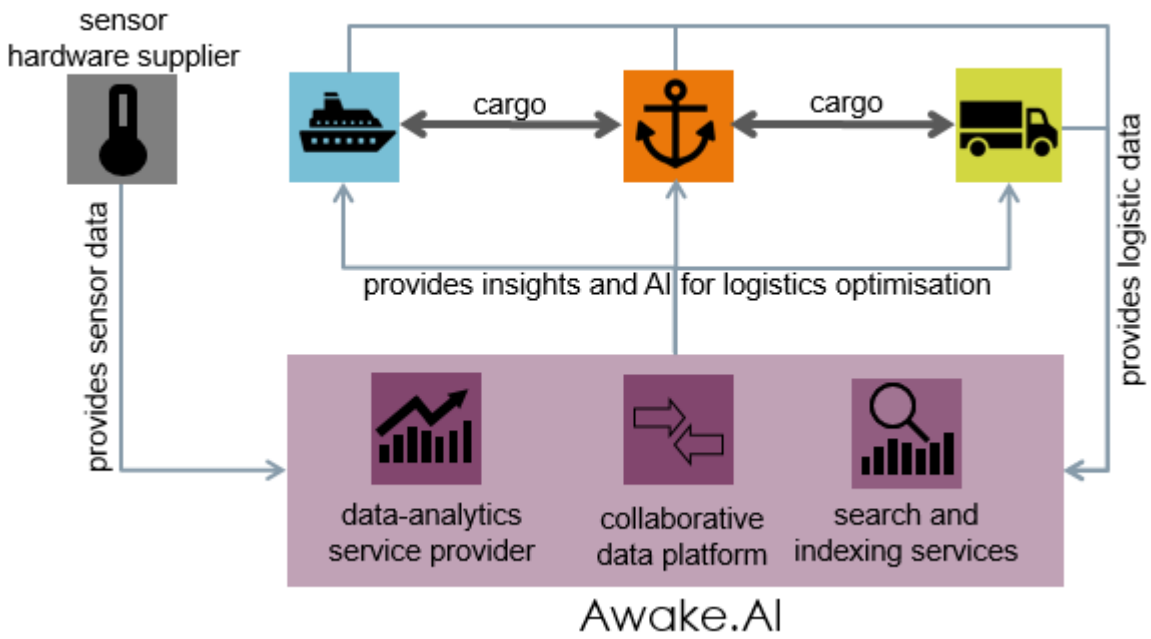


Actors in global maritime logistics operations are faced with increasingly stringent performance requirements and environmental regulations. However, today's maritime logistics chain is characterized by the so-called 4×40 problem: vessels sail empty up to 40 % of their sailing time and spend up to 40 % of their time waiting in port. Solving these problems holds the potential to improve operational costs by up to 40 % and reduce global shipping emissions by more than 40 %. Hence. There is a need for sea-port-land operations to become more interconnected and transparent, for information between the actors to become more fluid, and finally for the throughput to be maximized without environmental damage and investments in expensive physical infrastructure.

To address these challenges, Awake.AI offers a collaborative data platform that empowers digitalisation of sea, port and land operations. The platform provides a medium for better collaboration and planning between all actors involved in the maritime logistics chain. Its software combines raw data from all logistics operations and turns it into real-time insights, situational awareness and decision support for any maritime actor at their individual stage of in logistics process. Awake.AI offers the platform as an end-to-end solution that includes introduction to the platform, guidance upon functionalities, configuration of the customer's port (including installation of potential sensors) and calculation of potential cost savings prior to deployment.

By integrating IoT into the traditionally analogue processes of maritime logistics, Awake.AI equips operators to allocate their resources better, save time and resources, improve their profit performance and ultimately deliver more value to their stakeholders. Providing on top also AI-driven recommendations, the solution modernises the entire industry through operations optimisation, asset efficiency, Just-In-Time resource deployment and insights to plan future operations well in advance while making fuel consumption more efficient and reducing costs.

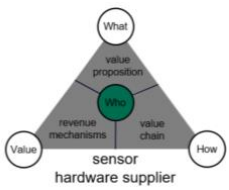
Value Network



In the value network, Awake.AI offers the collaborative data platform to all operators throughout the maritime logistics process, aiming to make all operations on sea, port and land more intelligent, efficient and sustainable. Awake.AI positions itself as a data aggregator to optimize the flow of information and thus optimization of the logistics between sea, harbor and land transportation.

Business Model Innovation

The business model changes of the enterprises considered in the value network example of Awake.AI can be summarized as follows:



Awake.AI is establishing itself as a new stakeholder in the value network, and thus, all four business model dimensions change significantly for the company. Due to the integration of Awake.AI into the network, also dimensions of the established partners' business models are subject for significant change.

The value chain of sea-port-land operators in the maritime logistics chain is significantly changed by using the platform for better coordination and planning of operations with partners. Also the value proposition and revenue mechanism change significantly, because they can offer additional data-driven forecast and planning services to their customers based on the insights provided by the platform, and in contrast to one-time payment for delivery, the additional data-driven services can be billed usage based.

The business model of the sensor hardware supplier is significantly impacted by a change in the customer segment with the integration of Awake.AI as new customer, whereas the remaining business is unaffected.

10. Cumucore - Private 5G mobile networks for Next Generation technologies.

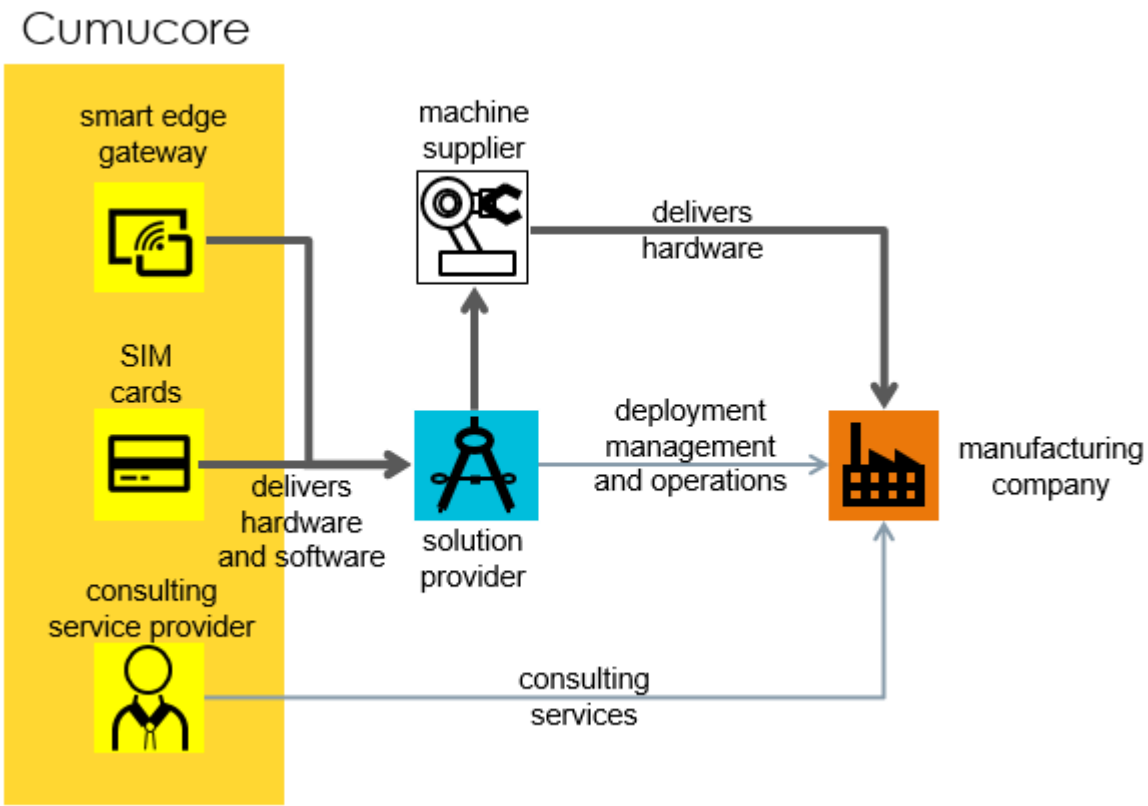
Overview

Along with an increased number of devices and generation of data has a societal need for increased network performance emerged. Communications networks have evolved from connecting billions of people to connecting hundreds of billions of things, and as the scale of the networks will continue expanding, the network management will become even more complex. In industrial setting, the requirement to connectivity has evolved from providing access to the internet to powering complex infrastructures. Previous generations of the network, such as 2G, 3G, and 4G, were configured to deliver download capacity because majority of data was transmitted to consumer environments end-user devices. Today however, data is increasingly transmitted to industrial environments and far more technologically advanced devices. However, the development has increased congestion in the network, and 4G is reaching the technical limits for the amount and speed of data it is able to transfer.

To address these challenges, Cumucore provides flexible standalone mobile network solutions to industry verticals. The solution covers a 4G and 5G Mobile Packet Core with reliable and easily compatible software for small-scale private LTE and industrial deployments. In addition to the software solution, the company also offers hardware components and provides consultancy services (while outsourcing deployment, management, and maintenance of the mobile network solution).

The mobile network solution simplifies mobile networks in the cloud or on-site while maintaining connection security and efficiency, thereby providing network performance that supports machine-to-machine communication, which enables users to deploy Next Generation technology applications such as real-time automation, augmented reality, drones, automated vehicles, robots, and warehouse and asset tracking in complex industrial infrastructures. Cumucore thereby responds to the need for connectivity posed by actors, especially in the verticals of Industry 4.0 and autonomous logistics. With their 5G solution, Cumucore delivers a gateway for the IoT-connected world at scale and for fostering the growth of data-driven industries.

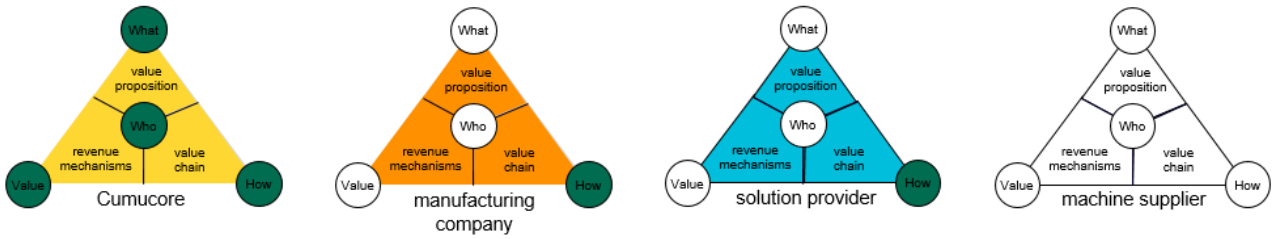
Value Network



In the value network, Cumucore offers the mobile network solutions to actors in various industry verticals, aiming to make 5G available in small-scale, non-public environments, and thereby democratize next generation connectivity and makes it more flexible and affordable for all private enterprises. Apart from offering the edge gateway, SIM and software to a solution provider, Cumucore focusses on offering tailored consulting services for its product and related products to the manufacturing companies. A machine supplier in collaboration with the solution provider delivers the hardware, in terms of machinery, and facilitates deployment, management and operations of it. Cumucore thereby provides the back-end connectivity and front-end guidance to the end-users.

Business Model Innovation

The business model changes of the enterprises considered in the value network example of Cumucore can be summarized as follows:



Cumucore is establishing itself as a new stakeholder in the value network, and thus, all four business model dimensions change significantly for the company. Due to the integration of Cumucore into the network, also dimensions of the established partners' business models are subject for significant change.

The value chain of the manufacturing company and the solution provider is significantly changed by the increased network performance delivered by Cumucore, which enrich the entire value creation process, where the manufacturing company benefits from increased production/machine automation, and the solution provider benefits from increased business due to deployment, management, and operations tasks. However, the value proposition, the revenue mechanisms and the customer segments served remains the same.

The business model of the machine supplier does not change as the company remains a contracted supplier and, for now, its position in the network is unaffected by the integration of Cumucore although communications networks will increasingly be one of the major forces driving the industrial world forward.

11. TEADAL - Industry 4.0 fast KPI calculation

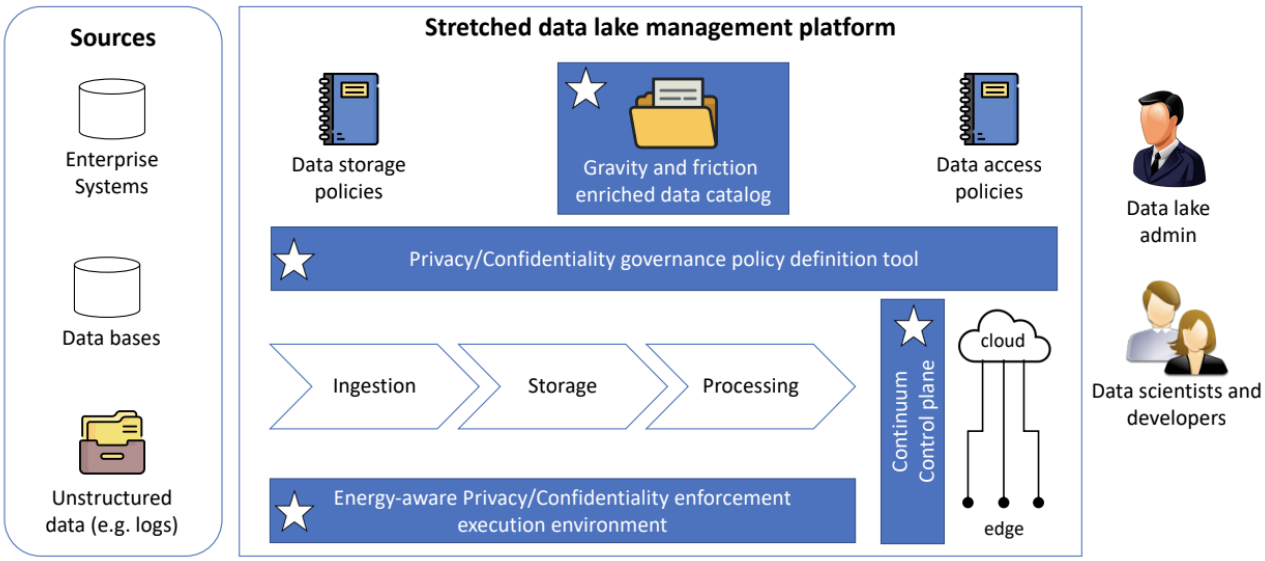
Overview

In an industry 4.0 setting, where IoT enables a continuous collection of data about the status of the processes, resources, and products. Data lakes give companies transparency to all the operations, allow data-driven and evidence-based decisions, and establish a level of trust between different departments and data sources.

A typical setting of a manufacturing company is represented by ERT who runs several industrial plants, thus with a big number of machines and with processes that are geographically distributed, which leads to a huge amount of generated data not always connected and analysed as one.

Having different workplaces requires a definition of how the production data is generated, stored, and shared inside and between all of the factories. Not forgetting that business intelligence data, such as production KPIs should be calculated according to the company standard, and not specific per each industry plant. However, sharing information requires both authorization and data protection, as not all information should be freely shared inside and outside an industrial plant.

TEADAL solution will be applied to two industrial plants of ERT (Portugal and the Czech Republic), to create a data lake federation able to manage both data at rest and data streams to compute KPIs which are relevant to acquire knowledge about the performances of the processes as fast as possible without breaking plant-specific policies about data management.



The ambition of TEADAL is to provide key cornerstone technologies to create stretched data lakes spanning the cloud-edge continuum and multi-cloud, providing privacy, confidentiality, and energy-efficient data management. The TEADAL data lake technologies will enable trusted, verifiable and energy efficient data flows, both in a stretched data lake and across a trustworthy mediatorless federation of them, based on a shared approach for defining, enforcing, and tracking privacy/confidentiality requirements balanced with the need for energy reduction.

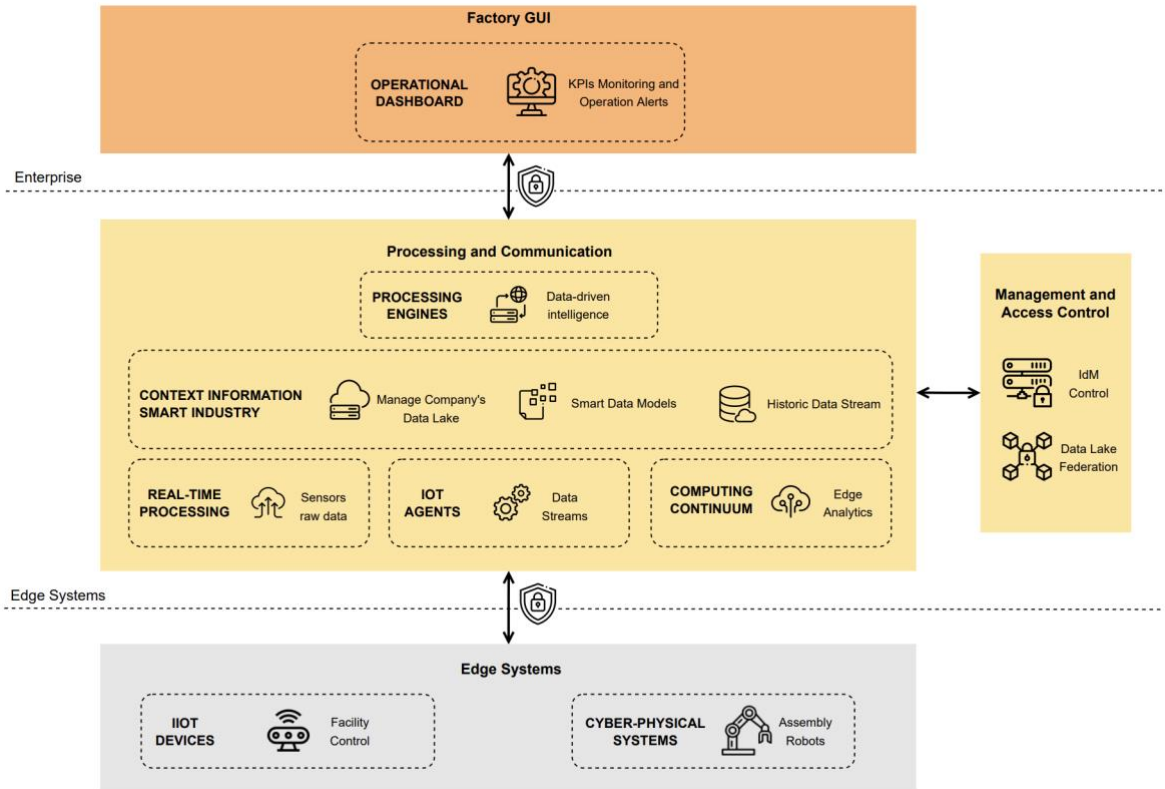
Value Network

In the value network, TEADAL offers a solution to be applied to two industrial plants (Portugal and the Czech Republic), where ERT's federated data lake will be created and the two data

types will be used. The first, data in-rest, will be related to data shared and generated inside each factory, and, the second, data-in-motion, will correspond to the data shared between the two industrial plants.

Also, TEADAL proposes a computing continuum and edge analytics solution. If sensor data from a manufacturing system points to the likely failure of a specific part, cloud edge can automatically shut down the machine and send an alert to plant managers. That can save time compared to transmitting the data to a central location for processing and analysis, potentially enabling organizations to reduce unplanned equipment downtime.

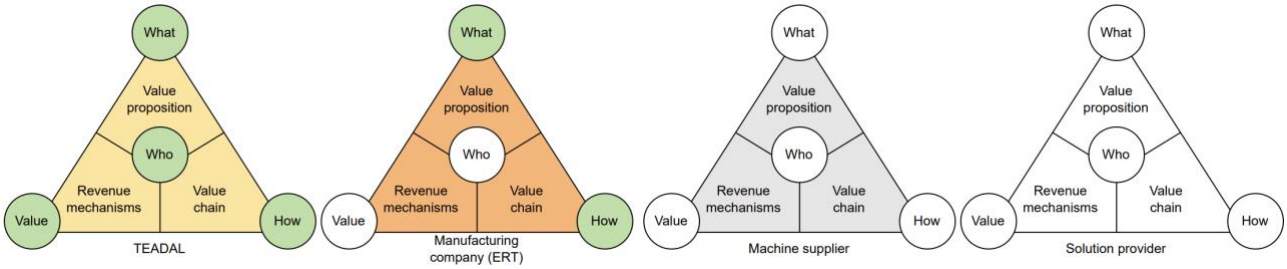
Moreover, the computing continuum at the edge layer enables scalability. Pushing analytics algorithms to sensors and network devices alleviates the processing strain on enterprise data management and analytics systems, as more connected devices result in more generated and collected data.



The TEADAL solution should rely on data from its collection and provisioning, during the development process, to all other stages of a product life cycle. This data should lead to information, knowledge, and other forms of data-driven intelligence. Finally, when shared inside or outside the factory, data should be stored at the company's federated data lake.

Business Model Innovation

The business model changes of the enterprises considered in the value network example of TEADAL can be summarized as follows:



The ambition of TEADAL is to propose methods, tools, and technologies needed to build a new generation of data lakes which will exploit the potential of the computing continuum to provide a more performant and energy-efficient data analytics while considering a federated setting to enable trustworthy data sharing.

The value chain of the manufacturing company and the solution provider is significantly changed by the privacy/confidentiality-aware data cataloguing for stretched data lakes, provided by TEADAL. Also, personal data or business sensitive data cannot leave the boundaries of the organization unless a proper data transformation satisfies privacy/confidentiality requirements, which is proposed to be addressed by the solution. This will lead to several benefits in the industry business, as TEADAL will provide tools and mechanisms to define a shared data governance where privacy/confidentiality emerges as a key point.

The business model of the machine supplier does not change as the company remains a contracted supplier and, for now, its position in the network is unaffected by the integration of TEADAL although communications networks will increasingly be one of the major forces driving the industrial world forward.

12. TRICK: High-value Textiles' Certification of Origin

Overview

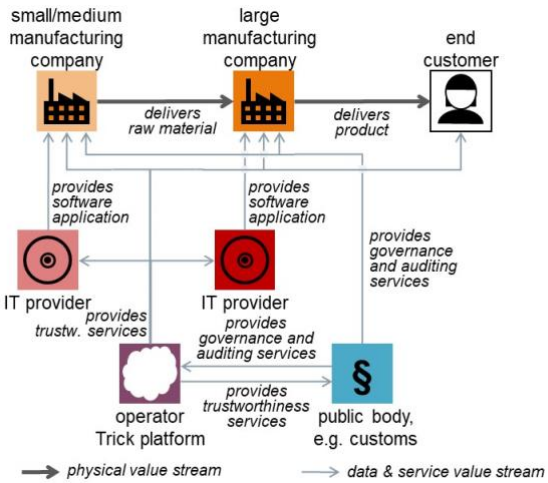
In EU a garment is worn an average of 3 times in its life, with €400 Bln lost a year discarding clothes which can still be worn and 92 Mln tons of waste, 87% of clothes ending up in landfills. But due to growing awareness on ethical and environmental impacts, 66% of consumers are ready to pay more for sustainable products.

The TRICK platform aims to collect the data and to save them in Blockchain to support the following services and their real implementations.

i) PCO - Preferential Certification of Origin: used by customs to calculate duties, based on product traceability.
ii) PEF: Product Environmental Footprint;
iii) CA: Circularity Assessment.
iv) HA: health protection assessment;
v) EA: Ethical Assessment;
vi) AI: AI for anti-counterfeiting based on big data analysis

More in detail, TRICK platform enables enterprises to collect product data and to access to the necessary services on a dedicated marketplace, open to third party solutions. To make the example for service i), secured traceability relies on the data needed for the preferential certification of origin (PCO), used for duty calculation. It will be certified by CUS - Italian Customs Agency, as member of the consortium, representing EU anti fraud public forces. The data extracted by the fiscal documents for the PCO are integrated with the data collected by machineries and the bill of materials, saved in the Blockchains (BC) per each lot of production to grant traceability continuity. These data are integrated with the additional ones to enable the six services provided by TRICK, indicated above. Blockchain secures information through the whole process, ending to consumers for informed purchasing. Data confidentiality and privacy are granted by the exploitation of Blockchains smart contracts while the adoption of different technologies are enabled by the development of Blockchain interoperability connectors between public and private Blockchains

Value Network



The figure shows the classic supply chain, in which small and medium manufacturing companies usually operate in the upper part of the supply chain, while larger manufacturing companies usually operate in the lower part of the supply chain.

In addition to the product, the end customer will receive further certificates in the future. The end customer can either obtain these certificates directly from the manufacturing company or obtain them directly from the trick platform.

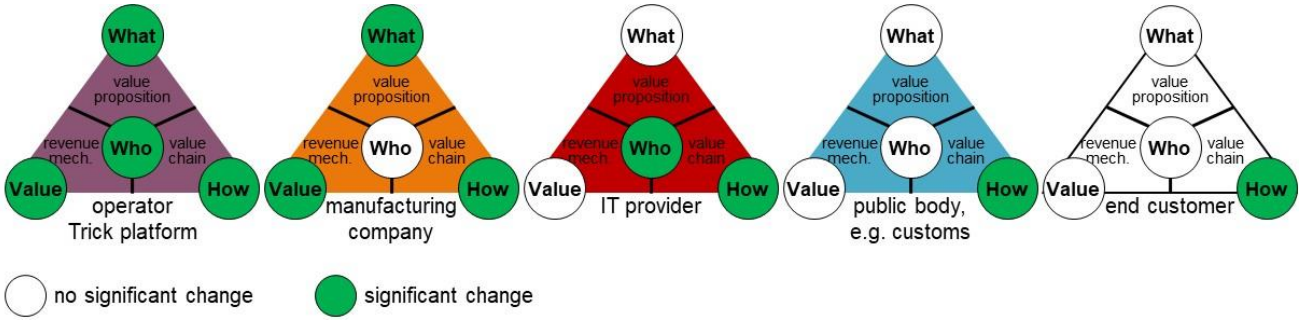
The public bodies, such as customs, define the legal framework, such as PCO, PEF, CA, HA, or EA (see above). In addition, public bodies also act as auditors. However, the auditors are usually different legal entities than those who define the governance.

IT providers deliver a software application to the manufacturing companies that allows the manufacturing company to provide the information and certificates required by the public bodies. Corresponding trustworthiness services of the TRICK platform are used for this purpose. Depending on the business model of the IT provider, the IT provider delivers a software application, which is then operated by the manufacturing company – in this case, the IT company does not necessarily consume trustworthiness services from the TRICK platform, or the IT provider provides this software application as a service – in this case, the manufacturing company does not necessarily consume TRICK platform's trustworthiness services directly.

Large manufacturing companies can also assume the role of IT provider themselves, while small manufacturing companies usually need an external IT provider. Typically, from the perspective of an IT provider, there are two market segments of manufacturing companies. IT providers often specialize either in small and medium-sized manufacturing companies or in large manufacturing companies.

The collection of data from production via IoT devices and the integration of this data into the corresponding IT systems of the manufacturing companies is not considered here.

Business Model Innovation



The operator of the trick platform is establishing itself as a new player in the value network, therefore all four dimensions of the business model are changing significantly. Since the operator of the trick platform offers its trustworthiness services to all other partners in the value network, the other partners have a new partner in their value chain and therefore their value chain changes significantly.

For the manufacturing companies (both large as well as medium and small), the value proposition changes because they provide additional certificates, on the basis of which the value of their goods will be increased and the revenue mechanism will take benefit. A manufacturing company could gain market share if it quickly implements new legal requirements.

In the case of IT providers, their previous basic value proposition – making a software application available – and their previous basic revenue mechanism do not change, even if the specific content of the software application changes here. Because of the trick platform, it is conceivable that IT providers will address their market differently. An IT provider that was previously focused on small and medium-sized manufacturing companies could now also address large manufacturing companies and vice versa.

Both the public bodies and the end customers do not change the dimensions of the addressed market, the value proposition, and the revenue mechanism because of the trick platform.

Conclusions

The various examples illustrate that the business impact of IoT in manufacturing industries is manifold. Without claiming to be complete, the various examples show the following effects on the value networks in the manufacturing industry:

- Companies use the (technical) capabilities of the IoT to establish themselves as a company in the value network of the manufacturing industry. Sometimes they take on roles that have not existed in this form before. In this sense, the IoT is to be seen as disruptive.

  In particular, the examples show the following two cases:

  - A company establishes itself as an IoT platform operator, i.e., its business purpose is to operate a so-called IoT platform and, as a result, to offer services to the users of the platform and to monetize them. Examples of this are Industrial Edge, DocuHub, MindSphere, and Awake.AI.

    These IoT platform operators act in the sense of a platform company according to the platform comprehension of Parker et al. [3] by bringing together different market sides. Without the IoT platform companies, these market sides are not being to establish a business relationship with each other in this way. However, the examples are characterized by the fact that the IoT platform not only brings together two market sides – as is often the case with B2C platforms – but three or more market sides in a complex value network.

  - A company offers new products and services to a dedicated customer. Examples of this are Aqua Robur, SEE.SENSE, HOP Ubiquitous, ASTI Mobile Robotics and Cumucore.

    These companies often provide intelligent sensors and devices as the core of their value proposition, often supplemented by related consulting services.

- Companies use the offers of the new companies in the value network to innovate their own business model. Examples are PRIMA, FIAT and SME in the BOOST 4.0 example and the sea, port, and land operator in the Awake.AI example.
- Companies use the offers of the new companies in the value network to optimize their own value-added processes without significantly changing their current business model. Examples are the operator water network in the Aqua Robur example, the operator infrastructure in the SEE.SENSE example, the manufacturing company in the ASTI Mobile Robotics and Cumucore examples.

From a technical perspective, many examples use an IoT platform. However, from a business perspective, the examples show two different applications uses of such a technical platform:

- The technical platform is used to earn money by operating the platform, see the examples for the IoT platform operators.
- The technical platform is used as a basis to offer own services. An example of this is See.Sense.

A company in the manufacturing industry should consider what position it assumes in the value network of the manufacturing industry today and what position it intends to assume in the future. They can use the examples described for inspiration, but they must make this strategic decision on their own responsibility. To be able to make well-founded decisions here, a company should get involved in appropriate communities such as AIOTI in order to discover and discuss their current and future business opportunities of the IoT.

References

[1] Digital business models for Industrie 4.0, Link

[2] The St. Gallen Business Model Navigator, Link

[3] G. Parker, M. Van Alstyne and S. Choudary: Platform Revolution, Link

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About AIOTI

AIOTI is the multi-stakeholder platform for stimulating IoT Innovation in Europe, bringing together small and large companies, start-ups and scale-ups, academia, policy makers and end-users and representatives of society in an end-to-end approach. We work with partners in a global context. We strive to leverage, share and promote best practices in the IoT ecosystems, be a one-stop point of information on all relevant aspects of IoT Innovation to its members while proactively addressing key issues and roadblocks for economic growth, acceptance and adoption of IoT Innovation in society.

AIOTI's contribution goes beyond technology and addresses horizontal elements across application domains, such as matchmaking and stimulating cooperation in IoT ecosystems, creating joint research roadmaps, driving convergence of standards and interoperability and defining policies. We also put them in practice in vertical application domains with societal and economic relevance.