Industrial Internet:
Putting the vision into practice

Industrial Internet business models
for machine and component manufacturers

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- What Industrial Internet & Industry 4.0 mean
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Introduction

The terms Industry 4.0 and Industrial Internet are used as synonyms in this white paper.

Industry 4.0 or the Industrial Internet is more than just a vision of the future. Using current technologies to connect physical objects to the virtual world is already yielding new business models. Machine and component manufacturers have an opportunity to drive forward their service business and secure their own personal competitive edge.

One potential first step is to expand and optimize services that already exist. By equipping machines and components with Industry 4.0 features and connecting them, companies can lay the foundation for collecting whatever field data they wish and aggregating it in a central location. Near real-time processing of this data enables rapid detection of faults and deviations, which means corrective action can be taken immediately. In addition, the accumulated data serves as a basis for new services – by applying data analytics, new insights can be acquired and subsequently transformed into new services. The example of predictive maintenance offers a particularly potent illustration of the principles and benefits of the Industrial Internet.

The Industrial Internet – The Internet of Things in production and logistics

Fifteen years have passed since Kevin Ashton, co-founder of the Auto-ID Center at the Massachusetts Institute of Technology, first coined the term Internet of Things (IoT). Today, this concept is acknowledged worldwide as one of the key innovation drivers in the business world. The new generation of the internet connects physical objects with the virtual world. The result is a global network of sensors, machines, and products that gives companies access to an unprecedented range of internet-based services offering extraordinary potential.

Exchange of up-to-date information in near real time helps boost efficiency throughout the value creation process.

The Internet of Things offers tremendous potential for the manufacturing industry. Machines, systems, products, ICT systems, and people can be progressively connected over the internet, creating a production network in which information carriers communicate with each other and exchange data and information in near real time. In terms of the value chain, this means value creation partners – from suppliers to customers – are more tightly connected and capable of entering into closer cooperation with each other. The exchange of up-to-date information offers an opportunity to improve the quality and timeliness of decision-making processes, optimize the coordination of activities, and boost efficiency throughout the entire value creation process. This, in turn, provides machine and component manufacturers with the chance to offer their customers new services.

Experts refer to this penetration of the internet into the manufacturing sector as the fourth industrial revolution, or simply Industry 4.0 (in the German speaking countries) or the Industrial Internet in the English speaking world. There is broad consensus that the incorporation and application of Industrial Internet technologies will lead to significant productivity gains and spur on growth. The future will see a shift away from separately demarcated product lines and factories to a situation in which machines, storage systems, and resources are interconnected worldwide as cyber-physical systems that can communicate with each other.

The **term Industry 4.0 or Industrial Internet** refers to, the fourth paradigm shift in production, in which intelligent manufacturing technology is interconnected. The first three were mechanization (steam engine), electrification (conveyor belt), and computerization (programmable logic controller / PLC).

Potential for machine and component manufacturers

The increasing interconnection of production and the internet offers a wealth of potential economic benefits, particularly for machine and component manufacturers. By connecting their products and expanding their range of services to include novel software solutions, they have an opportunity to leverage new market potential, compete effectively, and – in the best case scenario – gain a measurable edge over their competitors.

The Industrial Internet and the opportunities it offers

It is possible to achieve margins in the service business that are five to ten times higher than those obtained from simply selling a machine.

The service business plays a key role in the context of the Industrial Internet. To combat dwindling service revenues – primarily attributable to increasing standardization in the spare parts business – machinery manufacturers need to develop new business models. One fact is clear: the services offered by traditional machinery manufacturers are typically the most lucrative side of their business. According to the study "Service Business Development: Strategies for Value Creation in Manufacturing Firms" prepared by the University of St. Gallen in 2012, the service business can generate margins that are five to ten times higher than those obtained from simply selling a machine.

New technologies such as remote access and data analytics are prompting the required focus on the service business. By connecting their machines in the field, companies can access machine data during real-time operation. Intelligent evaluation of this data can offer new insights into issues such as what works in the field? And what functions might lead to faults in the field? These insights can provide a basis for developing needs-based services and applications and optimizing product functions for real-life use, which, in turn, has a positive impact on the product price.

The Industrial Internet starts today

In practice it is often difficult to know where to start when it comes to implementing the Industrial Internet. Will new, innovative applications and services genuinely provide significant added value? And when does it become worth investing in an Industry 4.0 project? Typically there are a multitude of different ideas within a company on what approach to take – and no defined strategy on how to proceed. One of the key challenges is to recognize that the implementation of the Industrial Internet is not a linear process. In many cases, new business potential will not become apparent until an Industry 4.0 project is well underway, or even after it has finished. Numerous opportunities may arise, and the consequences of each of these are difficult to assess. It is therefore sometimes necessary to make a major investment in an Industry 4.0 project without having a clear initial estimate of profitability because the component or machine manufacturer is entering unexplored territory with their innovation.

Equipping machines with sensors and software is a practical first step into the world of the Industrial Internet.

One practical and feasible first step into the world of the Industrial Internet for component and machine manufacturers is to expand and optimize their existing services. Equipping components and machines with sensors and software makes it possible to automatically collect a diverse range of field data. By connecting components and machines, data can be retrieved in near real time and gathered in a central location. In most cases, the knowledge required to interpret this data is already available within the company. This know-how can be modeled as rules and applied to the data automatically. Information previously obtained directly from the respective components and machines on the shop floor can now be visualized and monitored on a single platform using software.

This creates a tremendous degree of transparency. All the data is made available in an application-oriented format, making it much easier to identify faults or deviations and determine their exact nature. The result is a significant reduction in response times.
The ability to read the status of machines and production processes at any point in time and take targeted action when something goes wrong already constitutes a major improvement to a company's service business and a boost in its market position. But manufacturers can go one step further by applying data analytics, allowing them to prepare and analyze the accumulated data in order to transform new insights into concrete services. To reach this stage, it is necessary to equip products with sensors or software to generate the data required in the first place. This stock of data serves as a basis for making decisions on which services will be profitable and should therefore be provided by the company concerned.

Practical implementation of the Industrial Internet

Machine and component manufacturers have no time to waste because they are already in a position to implement value-adding services based on their existing service business. The Industry 4.0 innovation cycle shows how companies can make the best start and what concrete development process they should pursue in order to introduce new, useful services and continuously improve them.

The Industry 4.0 innovation cycle illustrates the concrete development process

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The continuous process of developing an existing business toward new services in the Industrial Internet is illustrated by the Industry 4.0 innovation cycle. The innovation cycle comprises three phases that a company passes through in one continuous process. It is also possible to carry out the phases in parallel.

The Industry 4.0 innovation cycle helps promote ongoing business development.

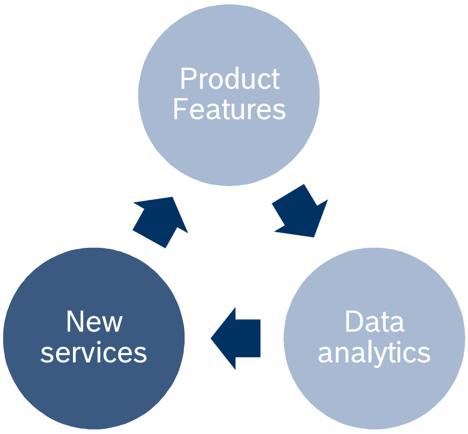

Figure 1: Industry 4.0 innovation cycle

Product features phase: The purpose of this phase is to equip the products (machines and components) with Industry 4.0 product features. These include sensors, actuators, an information processing system and machine-level software applications. In addition, the product must be connected in the field so that it can be accessed. The goal of this phase is for the product itself to generate data relating to its status and operation, to process this data on a product level, and to take any necessary action.

Data analytics phase: Equipping products with Industry 4.0 features makes it possible to collect many different types of data that can be generated and recorded by the products themselves. The purpose of this phase is to glean new insights from the accumulated data by applying data analytics. This provides a useful basis to assist in developing new services.

New services phase: The goal of this phase is to introduce new, useful services. The knowledge acquired in the previous phase can be used to derive new services for customers.

Modern process quality management without Industry 4.0

A manufacturing environment features a multitude of processes that take place in parallel. The quality of each process – such as a welding stage – has a direct impact on the quality of the final product. If a process is not carried out in compliance with the quality requirements, parts have to be reworked or scrapped. The later a quality issue is identified in the manufacturing process chain, the higher the costs incurred.
Process quality management aims to improve this situation by monitoring all processes to ensure that they meet the stipulated criteria in each case. If a process deviates from the specifications, immediate action needs to be taken in order to minimize – and ideally prevent – any lapses in quality. Many components and machines in modern manufacturing facilities already come with localized process quality monitoring systems. The results are viewed directly on the display provided on each individual component or machine. If a problem occurs, the operator sees the information on the screen (assuming he or she is physically present at the machine) and initiates the appropriate steps required to correct it.

Industry 4.0 product features

Sensors, actuators, and tailored software enable machines to be used in an Industry 4.0 environment.

In order to use a product – generally speaking, a machine – in an Industry 4.0 environment, it has to be equipped with certain features. These include sensors, actuators, an information processing system, and customized application software. The product also requires a network interface to provide it with a wireless or wired network connection in the field.
As well as ensuring these product features are in place, it is also necessary to set up a secure remote access to enable secure communication between the machine or component in the field and the supplier's system.

Machine manufacturers that offer this kind of product must clearly define the corresponding access rights. Any remote access must be approved by the machine operator or user, who has the ability to explicitly allow or refuse access in regard to both timing and duration. In some cases it may also be necessary to control components or machines using actuators. In principle, it is also possible to use remote access to install software updates, configure machine parameters, and even put machines into operation. That's why it is so important to clarify and clearly define control-level access rights. Once the required system of access rights is in place and the product is generating the required data, the task of optimizing existing services can begin.

Example: Innovative process quality management with Industry 4.0

Process quality management is a good example of how existing services can be optimized: Equipping products with the required Industry 4.0 features enables companies to take a centralized view of quality data drawn from a production process. An automated data analysis system can identify deviations in the production process and immediately inform the service operator, so the problem can be remedied without delay.

The next step: gaining knowledge through data analytics

As well as enabling the optimization of existing services, access to machines also opens up the possibility of collecting large quantities of data. It is important to clearly stipulate that data should be collected in order to meet the objectives in each case. Goals may include reducing maintenance costs by slashing the number of call-outs or reducing the cost of deviations in the manufacturing process, to name just two examples. The accumulated data consists of both historical and current data and forms the basis for the next step – data analytics.

It is important not to underestimate the quantity and complexity of the data acquired in the first stage. A multitude of sensors, components, and machines will typically produce enormous quantities of data, a phenomenon often referred to as big data.

Volume, velocity, variety – the three Vs that define big data.

Big data is a term for data sets so large, dynamic, or complex that they cannot be handled by traditional data processing applications. The definition provided by industry expert Doug Laney – which states that big data is characterized by the three Vs of volume, velocity, and variety – has become widely accepted by experts. The three Vs refer to the steady increases in data volumes, the high speeds at which data is transmitted (and, above all, generated), and the diverse formats in which data presents itself. Often, however, the term big data is also used as shorthand for the compilation of technologies that are required to analyze these large volumes of data, such as data analytics. It is important to remember, however, that good results in the Industrial Internet do not necessarily depend on the quantity of data involved, so it is important to check whether big data technologies are actually required in each individual case.

Data analytics is essentially a means of modeling and acquiring knowledge. The goal is to recognize patterns in data and develop predictive models on that basis. A pattern is a representation of an event in the form of data or a series of events in the physical world. In the context of data analytics, a distinction is made between descriptive and predictive analytics. The aim of descriptive analytics is to condense data and identify patterns. These patterns then form the basis for predictive analytics. By drawing on a number of different techniques – statistical methods, modeling, and machine learning, for instance – it is possible to predict what may happen in the future, such as forecasting the probability that a certain event or situation will occur. In order to predict events, the current flow of data is analyzed to detect known patterns. If part of a pattern is identified, then it is possible to predict how likely it is that the rest of the pattern will occur, and thus a certain event in the physical world. In an ideal scenario, the newly acquired information can be used to help automate decision-making processes.

Example 1: Improving process quality

Process data analysis provides transparency and minimizes the cost of faults and scrap.

Analyzing process data makes it possible to identify deviations in quality within a manufacturing process by identifying previously unknown patterns. Instead of a binary view of process quality as either good or bad, this technique enables quality trends to be depicted in a much more subtle and differentiated way. The user obtains comprehensive insights into the quality of production processes and is able to identify trends in quality over time and react to problems before a fault actually occurs.

This detailed form of data analysis has an additional benefit: in cases where no process data analysis is performed, some faults and deviations pass through the entire process without being detected and are only discovered at a later point in time. Greater transparency therefore helps manufacturing companies to reduce the cost of both faults and scrap. In addition, trends can be analyzed to pinpoint the best ways of optimizing how the machine or component is used.

Example 2: Analyzing machine data to detect wear at an early stage

Data analytics can be used to obtain accurate predictions of when a wear part will need to be replaced.

Another example of how data analytics can be used is in the management of wear parts – an application that shows how connecting objects to the virtual world can offer extraordinary benefits in the context of maintenance. The goal of any manufacturing company is to keep wear parts in operation for as long as possible in order to get the most out of their service life and reduce the use of materials. Two main types of maintenance are currently established in industry – reactive and preventive. In reactive maintenance, machines and components are only repaired when technical problems arise, with the resulting downtimes typically racking up significant costs. In contrast, costly wear parts are normally replaced at predefined intervals. This is a form of preventive maintenance in which parts are typically replaced more frequently than necessary, with the consequent waste of manpower and material resources.

By developing a suitable predictive model using data analytics, it is possible to determine the best time to replace a wear part based on machine or process data. As well as saving time on service and maintenance by reducing the frequency with which wear parts are handled and replaced, this strategy also reduces the use of materials. The more of these critical parts there are on a production line, the greater the savings that can be achieved in the maintenance arena. At the same time, this approach reduces unplanned downtimes to a minimum by identifying wear part failure at a sufficiently early stage.

New business models for maintenance

One example of an intelligent connection between a product and service is optimized condition monitoring with a corresponding service agreement.

In the future, machinery and component manufacturers will once again be able to generate bigger margins in their service business. The connection of a product and a service opens up new business models that can be continuously adapted to changing customer requirements and user expectations. One example is optimized condition monitoring with a corresponding service agreement. This involves monitoring components and machines via remote access and automatically triggering servicing and maintenance work where required. The recorded data is analyzed by the service provider in order to identify patterns that could indicate that a part is about to wear out or a machine is at risk of imminent failure.
This type of service paves the way for predictive maintenance. Machine condition data provides insights into deterioration and potential failure, while process data allows conclusions to be drawn on a machine's condition and the service or maintenance required. For example, deviations from the stipulated cycle time could indicate that the machine settings are suboptimal.

Connecting products and equipping them with suitable sensors, actuators, and software is an essential prerequisite for this kind of business model. Once access to the machines has been facilitated, traditional services such as reactive maintenance management can be offered in an optimized format. This kind of service provides detailed information on faults and deviations and comprehensive documentation of action taken. The manufacturers themselves benefit from these new business models because predictive maintenance enables them to order spare parts just in time, avoiding unnecessary storage costs.

The magic triangle illustrates a predictive maintenance business model

Who, what, how, revenue: a tangible business model based on predictive maintenance.

There is no doubt that companies will be able to generate revenue in the future with new business models based on existing Industry 4.0 technologies. But what form could this kind of integrated business model take in the field of predictive maintenance? The magic triangle developed by St. Gallen University gives a vivid illustration of how this kind of project could be developed in practice. The model defines four dimensions of predictive maintenance – who, what, how, and revenue – to take into account both in-house and external factors and create a comprehensive picture of all the issues involved.

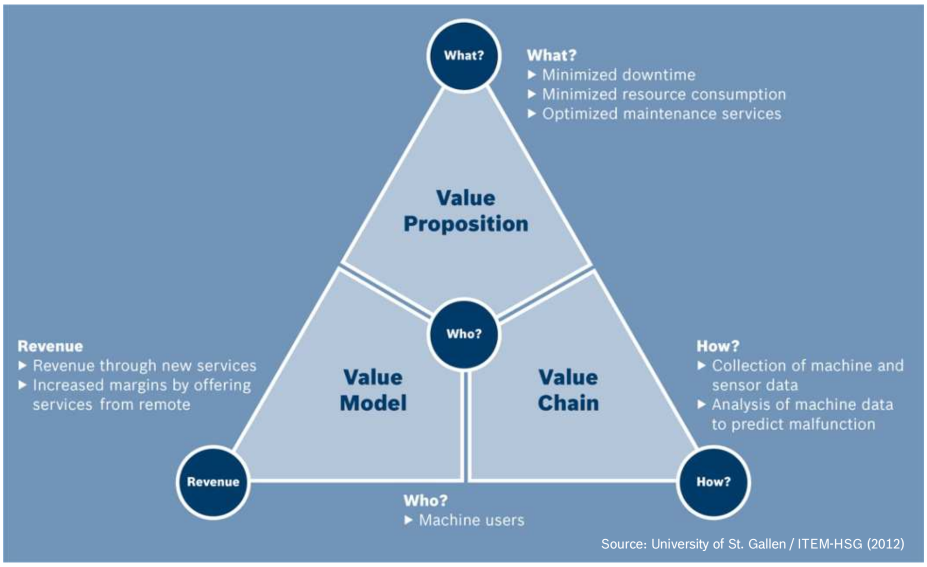

Figure 2: Magic triangle

The first question – **Who?** – is easy to answer. Machinery and component manufacturers and component developers would direct this kind of business model at their existing customer base and new customers. Typically these customers would be industrial manufacturing companies, in other words users of machines, systems, and components.

What exactly is offered to the customer? Predictive maintenance enables the machine manufacturer to determine at an early stage when maintenance should be performed at the customer site in response to an imminent machine malfunction. That enables machine manufacturers to offer their customers new services, such as guaranteed machine availabilities, while simultaneously reducing their own resource consumption. As well as assigning fewer employees to preventative maintenance tasks, the machine manufacturer also benefits from the fact that they only have to replace spare parts when there is a high likelihood of imminent problems. At the same time, users benefit from minimized downtime and a correspondingly higher production output.

The answer to the next question – **How?** – is that the current machine condition is recorded using sensor technology and automatically checked for patterns. This allows possible malfunctions to be detected at an early stage and machine failure to be averted.

Predictive maintenance services can help manufacturers improve customer satisfaction.

All of these factors put together provide the added value or **revenue** for the machine manufacturer – they are able to add new services to their existing portfolio in order to create an additional ongoing source of income. In addition, manufacturing companies save money thanks to the optimization measures. This provides another direct benefit to the machine manufacturer because the boost in customer satisfaction safeguards their business and helps the machine manufacturer stand out from the competition. A further advantage is that predictive maintenance requires remote access to machines and systems. This enables maintenance work to be carried out from a distance, which has a positive impact on the manufacturer's margins in the service business.

Summary

When it comes to the Industrial Internet, many manufacturing companies are waiting for a game-changing key technology to emerge – yet the increasing interconnection of production and the internet offers plenty of tremendously promising potential right now. Optimization of existing services is already yielding new business models, especially for machine and component manufacturers. The only step required to apply these models is to make products and systems Industry 4.0-ready by incorporating sensors, actuators, and information processing software. Once these foundations are in place, machine and process data can be analyzed and optimization measures implemented on the basis of this analysis. Predictive maintenance is just one example of the numerous possible applications of Industry 4.0.

In the long term, machine and component manufacturers will benefit from increasing customer satisfaction and higher turnover thanks to the continuous development of their service models. This will provide them with a means of distinguishing themselves from the competition and securing their long-term future.

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