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INDUSTRY 1.0 TO 4.0: THE EVOLUTION OF SMART FACTORIES

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ABSTRACT

An Industry 4.0 production system is thus flexible and enables individualized and customized products. The aim of this paper is to present and facilitate an understanding of Industry 4.0 concepts, its drivers, enablers, goals and limitations. The essence of the Industry 4.0 vision, the “Internet of Things”, is the ubiquitous connection of people, things and machines. This connection is intended to produce a variety of new goods and services. Products, means of transport or tools are expected to “negotiate” within a virtual marketplace regarding which production elements could best accomplish the next production step. This would create a seamless link between the virtual world and the physical objects within the real world. The term Industry 4.0 stands for the fourth industrial revolution. Best understood as a new level of organization and control over the entire value chain of the life cycle of products, it is geared towards increasingly individualized customer requirements. This cycle begins at the product idea, covers the order placement and extends through to development and manufacturing, all the way to the product delivery for the end customer, and concludes with recycling, encompassing all resultant services. The basis for the fourth industrial revolution is the availability of all relevant information in real time by connecting all instances involved in the value chain. The ability to derive the optimal value-added flow at any time from the data is also vital. The connection of people, things and systems creates dynamic, self-organizing, real-time optimized value-added connections within and across companies. These can be optimized according to different criteria such as costs, availability and consumption of resources.

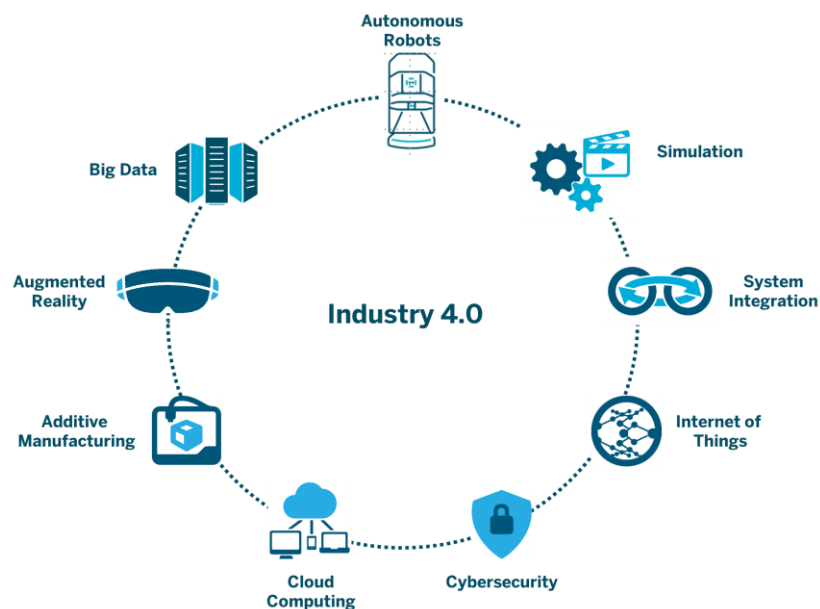
Keywords: *Industry 4.0, Internet of Things, Cyber Physical System, Smart Manufacturing
Cloud based Manufacturing, Enterprise-Resource-Planning*

INTRODUCTION

Our definition of the Industrial Internet or Industry 4.0 covers three aspects

- Digitization and increased integration of vertical and horizontal value chains
- Digitization of product and service offerings
- Introduction of innovative digital business models

The fourth industrial revolution – characterized by the increasing digitization and interconnection of products, value chains and business models – has arrived in the industrial sector. Our study, Industry 4.0 – Opportunities and Challenges of the Industrial Internet. It presents the essential attributes, opportunities and challenges posed by this development. They estimate the share of investments in Industry 4.0 solutions will account for more than 50% of planned capital investments for the next five years. The first significant driver for the advance of Industrial Internet solutions lies in the opportunity to integrate and better manage horizontal and vertical value chains. Companies surveyed expect more than 18% higher productivity over the next five years. While today only one fifth of the industrial companies have digitized their key processes along the value chain; in five years' time, 85% of companies will have implemented Industry 4.0 solutions in all important business divisions.



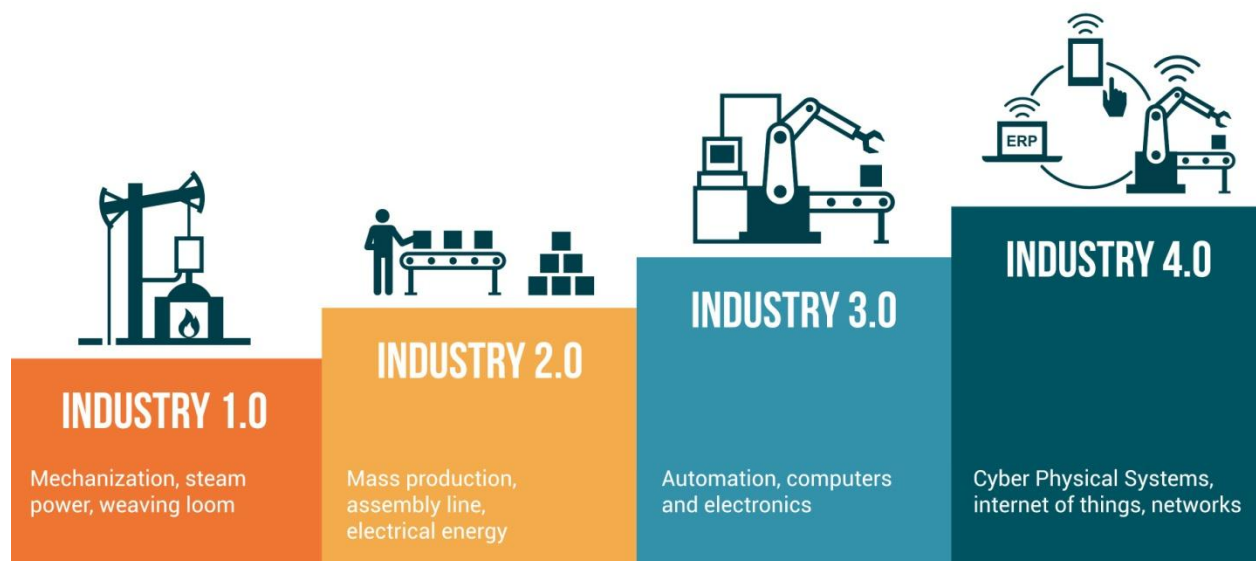
The digitization and interconnection of products and services (Internet of Things/Services) is a second important driver. It will contribute strongly to ensuring competitiveness and promises

additional revenues of 2% to 3% per year on average. A third major driver is the newly emerging, often disruptive, digital business models that offer significant additional value to customers through tailor-made solutions. These new business models are characterized by a considerable increase of horizontal cooperation across the value chains, as well as the integrated use and analysis of data. They are therefore capable of better fulfilling customer requirements.

The various opportunities, the large extent of change and the elevated need for investments make the Industrial Internet one of the most important topics for corporate management. However, the numerous challenges that the transition entails are also not to be underestimated. Besides the partly still unclear business cases for the Industrial Internet at company level, industry standards have to be defined and agreed upon and questions need to be answered, for example, in the area of data protection.

INDUSTRY 1.0 TO 4.0

For centuries, goods including food, clothing, houses and weaponry were manufactured by hand or with the help of work animals. By the beginning of the 19th century, though, manufacturing began to change dramatically with the introduction of Industry 1.0, and operations rapidly developed from there. Here is an overview of that evolution.



INDUSTRY 1.0 TO 4.0

INDUSTRY 1.0

In the 1800s, water- and steam-powered machines were developed to aid workers. As production capabilities increased, business also grew from individual cottage owners taking care of their own — and maybe their neighbors' — needs to organizations with owners, managers and employees serving customers.

INDUSTRY 2.0

By the beginning of the 20th century, electricity became the primary source of power. It was easier to use than water and steam and enabled businesses to concentrate power sources to individual machines. Eventually machines were designed with their own power sources, making them more portable.

This period also saw the development of a number of management programs that made it possible to increase the efficiency and effectiveness of manufacturing facilities. Division of labor, where each worker does a part of the total job, increased productivity. Mass production of goods using assembly lines became commonplace. American mechanical engineer Frederick Taylor introduced approaches of studying jobs to optimize worker and workplace methods. Lastly, just-in-time and lean manufacturing principles further refined the way in which manufacturing companies could improve their quality and output.

INDUSTRY 3.0

In the last few decades of the 20th century, the invention and manufacture of electronic devices, such as the transistor and, later, integrated circuit chips, made it possible to more fully automate individual machines to supplement or replace operators. This period also spawned the development of software systems to capitalize on the electronic hardware. Integrated systems, such as material requirements planning, were superseded by enterprise resources planning tools that enabled humans to plan, schedule and track product flows through the factory. Pressure to reduce costs caused many manufacturers to move component and assembly operations to low-cost countries. The extended geographic dispersion resulted in the formalization of the concept of supply chain management.

INDUSTRY 4.0

In the 21st century, Industry 4.0 connects the internet of things (IOT) with manufacturing techniques to enable systems to share information, analyze it and use it to guide intelligent actions. It also incorporates cutting-edge technologies including additive manufacturing, robotics, artificial intelligence and other cognitive technologies, advanced materials, and augmented reality, according to the article “Industry 4.0 and Manufacturing Ecosystems” by Deloitte University Press.

The development of new technology has been a primary driver of the movement to Industry 4.0. Some of the programs first developed during the later stages of the 20th century, such as manufacturing execution systems, shop floor control and product life cycle management, were farsighted concepts that lacked the technology needed to make their complete implementation possible. Now, Industry 4.0 can help these programs reach their full potential.

DISCUSSION

- The Industrial Internet, also known as Industry 4.0, not only comprises the digitization of horizontal and vertical value chains but will also revolutionize the product and service portfolio of companies – with the ultimate goal of better satisfying customer needs. The potential uses of the Industrial Internet go far beyond the optimization of production technologies. However, exploiting these opportunities requires considerable investment. The topic therefore inevitably occupies a leading position on the agenda of directors and managers of industrial companies.
- Over the next five years, the industrial companies surveyed will invest, on average, 3.3% of their annual revenues in Industrial Internet solutions. This is equivalent to nearly 50% of the planned new capital investments and an annual sum of more than €140 billion. These investments will have to be used along the entire value chain in order to achieve maximum success. The companies expect that 86% of the horizontal and 80% of the vertical value chains will have a high degree of digitization by 2020 and will therefore be closely integrated.
- The industrial sector is required to produce ever larger quantities using fewer raw materials and less energy. The Industrial Internet allows higher productivity and resource efficiency and thus creates the conditions for sustainable and efficient production. The

companies surveyed anticipate an average efficiency increase of 3.3% per year across all industry sectors due to the digitization of value chains. This amounts to a total of 18% in the next five years. They expect annual savings of 2.6% with respect to cost reduction.

- The Industrial Internet will have a lasting effect on existing business models and will particularly also Generate new, digital – often disruptive –business models. The focal point of this trend comprises increasing customer benefits through a growing range of value solutions (instead of products) and increased networking with customers and partners. The special quality of the digital change lies in the rapid acceleration of the speed of change. Disruptive innovations will also cause industry sectors like the information and communications industry to sustainably transform within a short period of time.
- Companies have to master several challenges on the way to becoming a Digital 4.0 champion. The main focus is on high investment levels and often unclear business cases for new Industrial Internet applications. Furthermore, sufficient skills to meet the needs of the digital world must be ensured.
- Binding standards must also be defined and tasks in the area of IT security have to be solved. Policy-makers and industrial associations can help with these latter challenges in particular, by advocating uniform industrial standards at a European or international level and promoting efficient rules for data security and data protection

CONCLUSION AND FUTURE WORK

Digitization will have a permanent effect on our living and working environment. This development offers the full range of opportunities for the industrial sector to expand its leading global position. New, digital business models will expand the existing product and service portfolio in order to ensure future growth in sales. The implementation of the Industrial Internet represents a multi-year transformation process for the majority of companies, resulting in significant changes to their value chains. The term Industry 5.0 has been introduced to the research areas which are considered as next industrial revolution, but it is more systematic transformation that includes impact on civil society, governance and structures, and human identity in addition to solely economic/ manufacturing ramifications.

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