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INDUSTRY 4.0: THE SMART FACTORY OF THE FUTURE IN BEVERAGE INDUSTRY

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15.1 Introduction

The food and beverage industry are increasing its importance from day to day (see Fig. 15.1). While the sensory experience of food and drinks are so varied and human happiness is constantly improving, searching for innovation, catching the standard in taste, and responding quickly to requests are bit more risky than other sectors.

People consume an average of between 3 and 5 L of beverages per day as coffee breaks are very common these days. Beverages are indispensable to people. In other words, beverage is classified under fast-moving consumer goods (FMCGs). It is an inevitable fact that we seek to innovate and obligate the producers in the products that we consume so fast. The product life cycle of beverages is becoming shorter and shorter. Nowadays, in the United States and the United Kingdom the latest in beverage trend is cold brew coffee. According to the Beverage Trends Report 2017 published by Google, across the four markets, process-based drinks such as cold brew, infusions, and raw are prominent among the top trending beverage searches (Horwitz and Zimmer, 2017). Beverage companies should be looking at a number of areas in order to maximize growth: leveraging consumer insights, focusing on rapidly expanding emerging markets and looking for acquisition opportunities, optimizing business process and following digitalization trends, etc. Ongoing volatility in the global economy means that the companies are operating in an environment that is increasingly unpredictable. Consumers are changing, becoming value-focused across all product categories, more connected, and in control. To compete globally, the companies must reinvent their approach: becoming swift and agile, seizing opportunities to innovate,

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Fig. 15.1 Development of the beverage sector.

and establishing greater control over their supply chains. Optimizing the operating model is critical and this means striking the right balance between local autonomy and global scale and efficiency. A globally consistent strategic direction gives the ability to draw on capabilities and resources from anywhere in the world. Thus, companies can provide rapid response to evolving market needs.

Martin indicated that commercial demands were putting pressure on the supply chain to be increasingly efficient—offering faster stock replenishment, more variety of product or ranges tailored to individual shops or market areas. Companies needed to improve the integration of the supply and demand sides of their businesses in order to manage those pressures. Beverage companies should produce products that are both innovative and healthy. In US brewing, there has been an upsurge in the production of craft beers while health and wellness remain a focus for certain soft drink companies. The Coca-Cola Company has founded the Beverage Institute for Health and Wellness, to respond to this trend. Focus on health is also a factor driving innovation toward packaging. In the United States, where soft drinks have for the last two decades been served in increasingly large servings, the trend is starting to reverse as calorie-conscious consumers seek smaller sizes and younger consumers seek to consume on the move. Smaller sizes also enable manufacturers to position products at lower price points. Environmental factors are also driving new packaging types: both the Coca-Cola Co. and PepsiCo have developed 'green' recyclable bottles that are made from plant-sourced materials (Martin and Wills, 2012).

In order to make the change manageable, the manufacturers have used technological opportunities. Adoption of technology is accelerating. Businesses now face a far faster business cycle where they have to react rapidly "in real time." Companies need to experiment quickly and cheaply, and focus on relevant contact with the consumer, as well as with content. It is estimated in 2013 that two billion users will make purchases using mobile devices such as smartphones. According to the spokesperson, social media is a living, breathing marketing tool that forms a vital part of a healthy integrated marketing strategy. The power of the Internet and social media is of great importance to producers and consumers. The purpose of the consumer is to reach the product they are looking for quickly, and the consumer is to produce it agile and reduce the costs. Glendinning indicated that they believed that reducing cost must be a way of life for them to be competitive in the industry in the long term. These problems are driving the development of industrial technologies to reduce the labor force, to shorten the development time of the product, to use resources efficiently, and so on, of which the cyber-physical systems (CPS) and Internet of things (IoTs) are two state-of-the-art technologies advanced within the last decade (Martin and Wills, 2012).

These problems will be improved a bit with the new era of the industry. Industry 4.0 was introduced by the German authorities during the Hannover Fair in 2011, which symbolizes the beginning of the fourth Industrial Revolution. Since its first publication, many European manufacturing research organizations and companies have produced work on this topic, which emphasizes that under Industry 4.0, manufacturing will consist of exchanged information and controlled machines and production units acting autonomously and intelligently in interoperable systems. However, researchers hold different opinions of the specific requirements of Industry 4.0 and its accomplishment, acting on their various industrial technology applications. It is obvious that modern manufacturing is a generalized topic, which is elaborated in multiple fields. Therefore, the current understanding of Industry 4.0 cannot claim the principles. In addition, the manufacturing industry is desperate for a hierarchical procedure of technological application, which will guide people to fulfill Industry 4.0 (Qin et al., 2016).

Industry 4.0 has been defined as the next phase in the digitization of the manufacturing sector, driven by four disruptions: the astonishing rise in data volumes, computational power, and connectivity, especially new low-power wide-area networks; the emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction such as touch interfaces and augmented-reality systems; and improvements in transferring digital instructions to the physical world, such as advanced robotics and three-dimensional (3D) printing. Most of these digital technologies have been waiting for some time. Some are not yet prepared for implementation at scale. But their greater reliability and lower cost are starting to sound meaningful for industrial implementation. However, companies are not consistently aware of the emerging technologies. According to the researches in January 2015, of the 300 manufacturing leaders, only 48% of manufacturers consider themselves ready for Industry 4.0. A total of 78% of suppliers say they are prepared (Erol et al., 2016; Qin et al., 2016).

According to Taylor, the basic rationale of industrialism is that you can manage what you can measure. Today, this is impossible without using technology. Given below is the reinforce output of Industry 4.0 with examples.

Big Data: An African gold mine used sensors technology in order to capture more data from its sensors. New data showed some unsuspected fluctuations in oxygen levels during coating, a key process. Fixing this increased yield by 3.7% is worth up to $20 million annually.

Advanced analytics: In order to improve product development, a stronger analysis is necessary. One automaker uses data from its online configurator together with purchasing data to identify options that customers are prepared to sacrifice a premium for. With this knowledge, it reduced the options on one model to just 13,000—three orders of magnitude fewer than its competitor that offered 27,000,000. Development time and production costs fell dramatically; most companies can improve gross margin by 30% within 24 months.

Human-machine interfaces: Picking technology has been developed through using augmented reality (AR) by the company Knapp AG. Pickers wear a headset that presents vital information on a see-through display, helping them locate items more quickly and precisely. And with both hands free, they can build stronger and more efficient pallets, with fragile items safeguarded. An integrated camera captures serial and lot ID numbers for real-time stock tracking. Error rates are down by 40%.

Digital-to-physical transfer: Local Motors builds cars almost entirely through 3D printing, with a design crowdsourced from an online community. It can build a new model from scratch in a year, far less than the industry average of six. Vauxhall and GM, among others, still bend a lot of metal, but also use 3D printing and rapid prototyping to minimize their time to market (Baur and Wee, 2015; Stark, 2016).

15.2 Concept of Industrial 4.0

This section describes the concepts of Industrial 4.0 that influenced the industry, the historical origination of the term, and the definition.

15.2.1 Concepts of Influenced the Industry

Manufacturing industry is subject to significant structural changes owing to globalization. According to Westkämper (2013), several ongoing developments influence the entire manufacturing industry.

Customization: People like to use manufactured product to them. The consideration of customer desires in many industries such as textile, automation, beverage, furniture, and machines has come to determine the product level standards. For example, on the product had a lot of traditional names written by the Coca-Cola Co. If we mention another example; 3D printer, a product produced by an entrepreneur has been used to create a picture on top of the latte and thus the service industry is solicitous about this product. In a word, people desire to feel exclusive. The benefits of traditional industrial mass production based on automation, economies of scale, and knowledge through experience, which have been the fundament of international operating manufacturing companies for a long time seem to disappear smoothly (BMWT, 2010). More and more attention tends to the customer's wishes and individual needs that let's the degree of customization products increase crucially at the present time. Due to the fact that manufacturing industry becoming more of an issue swiftly makes a design. This condition poses a lot of problems for the firm that the items have no standard cost, product tree, technical drawing, and documentation. If the company's production structure is ready for the customer's need, it keeps ahead of the game. Companies should manage their product life cycle.

Volatility: The global crisis has shown us that coping with short-cycled, fluctuating markets is a crucial factor to stay competitive. Spath et al. (2013) emphasize the term volatility, as the dictate of the moment. Volatility by definition means "likely to change suddenly and unexpectedly." Volatility is perceived as the main driver for a paradigm shift in manufacturing, inasmuch as it requires more flexible and adaptable structures, processes, products, and systems in manufacturing. Future companies will have to invest in flexibility and adaptability, as the classical instruments will not be able to master volatility any longer.

Energy and Resource Efficiency: The purpose of the industry is to provide the most optimal use of the intended resources. Even though industry has destroyed nature since the beginning of the production owing to the fact that natural resources are being used, nowadays, manufacturing firms are beginning to make life cycle assessment (LCA), which measure the effect of the raw material, production process, and recycling. Hence, while a new product is to be designed or an existing one is to be improved, this assessment data are used, and the industry can design or provide more sustainable products. Companies that aim to produce sustainable products will be in a more goodwill status in the competitive environment. In the long term, a sustainable and secure supply of raw materials will lead to an exponential increase in demand for energy, mineral and raw materials. According to expert forecasts, the overall demand will double until 2050. Resource productivity and resource efficiency should be included in the strategic goals of each manufacturing company. Any waste in production, which, for example, is caused by overproduction, quality issues, or unused potential for optimization, has economic and social consequences (Notarmicola et al., 2017).

15.2.2 Historical Development of Industry

The process of industrialization started with the introduction of mechanical equipment at the end of the 18th century. The steam engine was modified thanks to James Watt which helped in the mechanization of work areas. For example, there was tremendous transformation that took place in print jobs and in weaving industry with the advent of steam engines. First, the transformation from an agricultural to an industrial society was introduced. First industrial revolution provided decrease of scarcity in the industrial-oriented countries thereby increasing population. Immediately after that, the second industrial revolution coincides with the first quarter of the 20th century. In the period, oil-driven internal combustion engines were developed. This revolution was predominantly coined by organizational changes such as the implementation of Henry Ford's assembly line and the scientific management procedures based on Frederic W. Taylor, better known as Taylorism. The fact that factories became electric, supported mass production. Significant improvements have been made in oil production and refinery in order to meet the rising energy demand. The cities began to grow rapidly; business and accommodation in developed countries began to differentiate. Production volume and product range started to increase. Then, it is a well-known fact that there was an overconsumption of natural resources and that a sustainable world became a challenge. People began to realize that they need to reduce energy consumption and the third industrial revolution included both automation and sustainability. In this period, digitization of production can be considered as the first step. The Internet began to become widespread with the development of information and communication technology (ICT). The communication tools that use the satellites and cordless technology have laid the foundations for distributed communication. In this period, efficient use of natural resources, renewable energy, and globalization has become crucial concepts. Terminally,

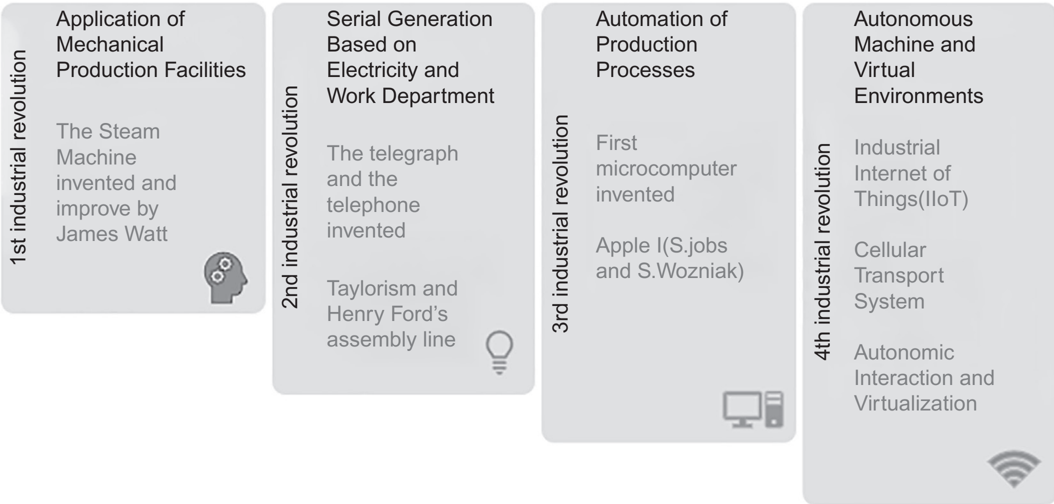

Fig. 15.2 The stages of industry.

the industry is in fourth period with beginning of development of the Internet infrastructure. Industry 4.0, which was first mentioned in the Hannover Fair in 2011, took its place in today's industry with the support provided by the German Federal Government. Countries such as the leading technology giants the United States and Japan have supported this industry and have planned their future goals according to Industry 4.0 (see Fig. 15.2).

Industry 4.0 general lines: the complete takeover of production by robots, the development of artificial intelligence, the production of 3D printers, the removal of fabrics from houses, the massive accumulation of information by data analysis, and many other innovations.

All in all, while production volume was increasing, manufacturing field and sectors rate grew mature. The issue of marketing and selling what has been produced took its place in production problems. As the quantity and variety of products expanded, an image appeared as if the customer volume had narrowed. Thence, new approaches and methods have been brought on in marketing and sales thanks to Big Data management from the beginning of the industry to this time. Today's mechanical developments are realized by automation and software that's why robots are used instead of workers. The developments show that the plants without the light are not far away.

15.2.3 The Definition of Industry 4.0

Scholars have defined Industry 4.0 from diverse perspectives in this research category. For instance, according to the Consortium II, Fact Sheet (2014), Industry 4.0 is the integration of complex physical machinery and devices with networked sensors and software, used to predict, control, and plan for better business and societal outcomes. Henning and Johannes define Industry 4.0 as a new level of value chain organization and management across the life cycle of products. Hermann et al. (2015) define Industry 4.0 as a collective term for technologies and concepts of a value chain organization. They note that within the modular structured Smart Factories of Industry 4.0, CPS monitor physical processes, create a virtual copy of the physical world, and make decentralized decisions. They point out that over the IoT, CPS communicate and cooperate with each other and humans in real time, and that the IoSs, both internal and cross-organizational services, are offered and utilized by participants of the value chain. So far, there is no unanimously adopted definition of Industry 4.0. Sendler (2013) and Kagermann et al. (2013) mention CPSs along with the Internet of things and services (IoTSs). Both authors state that these technologies will be the basis for the evolution from the third to the fourth phase of industrialization. As concerns the IoTSs, Spath et al. (2013) allege that the current developments in social media, social web, and web 2.0 will get in manufacturing environment the identical way they entered private households. According to Kelker (2011), Big Data and human machine interaction are technology developments, which will form the future of the manufacturing system. Big Data technologies analyze and process huge volumes of collected data, multimodal human-machine interfaces, for instance, touch displays and gesture recognition will allow employees to generate wholly new levels of communication and interaction in a manufacturing environment. According to the Capgemini Consulting, cloud computing, advanced analytics, mobile computing, machine-to-machine communication, advanced robotics, community platforms, and 3D printing are the seven core technologies that will affect the manufacturing sector positively. McKinsey & Company strategic consultancy published a report on Industry 4.0 and digitization of the manufacturing sector that included 45 countries. A significant point is that the migration from traditional to digital, the shift from online to mobile, and the transition from ownership to access are progressing even faster than expected. According to the report, Industry 4.0 disrupts the value chain and companies need to rethink the way they do business. They need to drive the digital transformation of their business in order to succeed in the new environment. The are five pillars that are critical for this transformation: first, companies need to build digital capabilities. These include factors such as attracting digital talent and setting up cross-functional governance and steering. Second, companies need to enable collaboration in the ecosystem. These require getting involved in the definition of standards and cooperation across company borders through alliances, strategic partnerships, and cooperation in communities. Third, data should be managed as a valuable business asset; hence, they need to secure crucial control points. Fourth, the companies need to manage cybersecurity end to end to protect digitally managed shop-floor operations and proprietary data. Lastly, the companies need to implement a two-speed systems/data architecture to differentiate quick-release cycles from mission-critical applications with longer turnaround times.

To leverage multiple opportunities, the companies need to embark on a digital transformation journey: a continuous, long-term effort is needed to navigate successfully the changing industrial environment of Industry 4.0. In the following section, we will see the technologies required for Industry 4.0.

15.2.3.1 New Technological Possibilities for the Future of Manufacturing

The technologies required Industry 4.0, such as IT-enabled manufacturing and increased computing capacity, to hold the promise of smart factories that are highly efficient and increasingly data integrated. Data are the core driver: leaders across industries are leveraging data and analytics to achieve a step change in value creation. A big data/advanced analytics approach can result in a 20%–25% increase in production volume and up to a 45% reduction in downtime. McKinsey's research shows that all of the following technologies, for various reasons, are at a tipping point today and are ripe to disrupt the manufacturing value chain. To be more precise, there are four clusters of technologies that need to be examined (see Fig. 15.3). Different drivers are leading to an acceleration of use on a large scale for each of these clusters.

In short, the ongoing developments and elaborations on future technologies in manufacturing are the driving force for research initiatives in this area. In this section, it becomes very clear that nearly every market player (private and public) yields to define, explain, and create a "big picture" of the future of manufacturing in order to keep the pace with others. This has certain legitimacy, although a deeper understanding of the concepts, ideas, and technologies as well as its relations is needed, especially for the implementation in practice.

15.2.3.2 Central Features of the Concept

Industry 4.0 should not be contemplated as a closed system; on the contrary, it should be considered as one essential part out of several key areas. In a smart, interconnected world based on the IoTSs the economic key sectors will be transformed into smart infrastructures and cluster. This transformation leads to the emergence of smart networks and smart buildings in the field of energy supply, smart

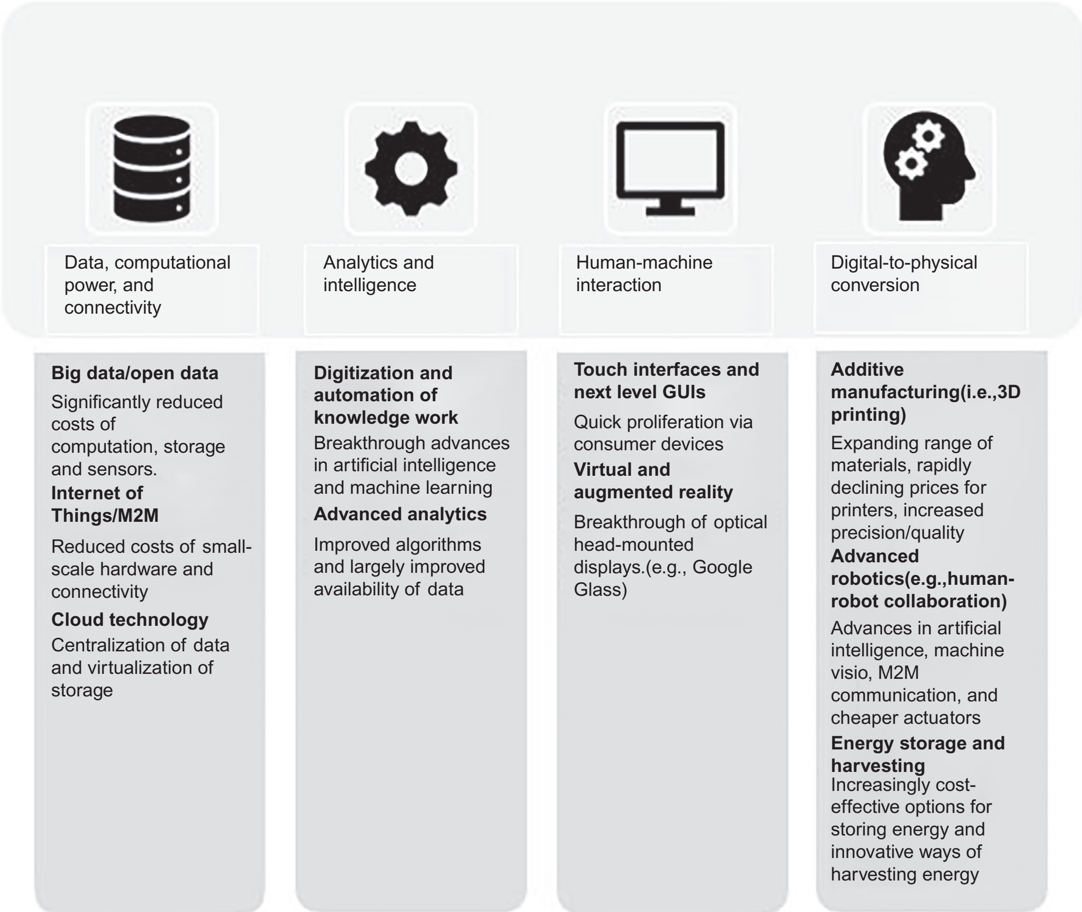

Fig. 15.3 Digitization of the manufacturing sector.

and sustainable mobility and logistics solutions, smart health, and so forth. Consequently, Industry 4.0 should be conceived, implemented, and lived in an interdisciplinary attitude and close cooperation with the other key areas. Within this smart ecosystem, Industry 4.0 is the manifestation of the "smart thinking" approach in manufacturing environments (see Fig. 15.4).

The term smart factory, being central of Industry 4.0, is significant. According to experts, smart factory has several characteristics, companies that are able to solve complex and unexpected problems as well as to manufacture products more efficiently. In the smart factory, worker, machine, and resources communicate with each other as naturally as in a social network.

In implementing Industry 4.0, the aim is to create an optimal overall package by leveraging the existing technological and economic

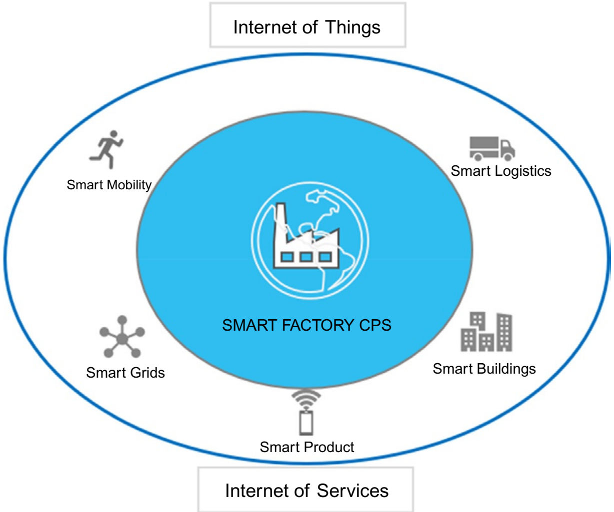

Fig. 15.4 Smart factory in the center of the concept Industry 4.0.

potential through a systematic innovation process drawing on the skills, performance, and know-how of Germany's workforce. Industry 4.0 will focus on the following overarching aspects:

- *Horizontal integration through value networks*: Realms of research, development, and implementation are performed evenly. In addition to business model and shape of collaboration, between different companies, it is also necessary to address topics such as sustainability, know-how protection, standardization strategies, and medium to long-term training and staff development initiatives.
- *End-to-end digital integration of engineering across the entire value chain*: While technological complex system is increasing, it plays a management key role. IT system should be deployed to provide end-to-end support to the whole value chain as product development, manufacturing system engineering, and produce and service. A holistic system engineering approaches is essential, which includes different technical disciplines.
- *Vertical integration and networked manufacturing systems*: In tomorrow's smart factories, the manufacturing structures will not be fixed and previously defined. Instead, a set of IT configuration rules will be defined, which can be used on a case-by-case basis to build automatically a specific structure for all cases, including all related requirements in terms of model, data, communication, and algorithms.

In order to provide vertical integration, it is essential to deliver end-to-end digital integration of actuator and sensor signals at different levels right up to the enterprise resource planning (ERP) level.

For providing a temporary network of manufacturing system and reconstruction, modularization and reuse strategy need to be improved. Moreover, headworker and worker training is required in order to understand the effect of the approach.

These three important features of the transformation process will have a well-rounded influence not only on economic levels in the form of new business opportunity and new commercial model but also in terms of new social structures, organizational structures, and legal concerns.

The job definition, the necessary qualification, and innovative interaction in the form of wide human-machine collaborative will have a significant impact on future socioeconomic work systems. New emerging, interconnected value chains will change traditional business models and organizations from vying market players to collaborative rivals.

15.3 The Key Technological Concept of Industry 4.0

In this section, the key technological concepts, namely CPSs, the IoTSs, intelligent object, artificial intelligence, and augment reality, and 3D printer will be described in detail.

15.3.1 Cyber-Physical Systems

Preliminarily, it should be kept in mind that behind Industry 4.0 there is no such thing as one and new single Industry 4.0 technology. CPS defines that ICTs continuously advance with computing, communication, and storage capacity exponentially growing in order to expose more powerful, interconnected new technologies. CPS are making possible technologies which get virtual and physical worlds combine together to create a network, where intelligent things communicate and interact with each other. CPS were previously generated from embedded systems.

CPS, ensure the base for the creation of IoTs that combine with IoS in order to enable Industry 4.0. If the boundaries between virtual and real worlds disappear, they enable multiple innovative applications and processes. If between virtual and real worlds boundaries disappear, they will enable multiple innovative applications and processes. Thus, they revolutionize our interactions with the physical world in much the same way that the Internet has transformed personal communication and interaction. The interplay between high-productivity software base of embedded systems and assigned user interface that are integrated digital networks creates a purely new world of system functionality. CPS symbolize a paradigm break from the current business and market models, such that revolutionary new applications, service providers, and value chains become possible.

Revolutionary applications will facilities new value chain models, turning into classic industries for instance the automobile, beverage, energy and production engineering. Globalization and urbanization are forces that transform more enabling technological solutions for a world in flux. Future cyber-physical system will promote safety, efficiency, comfort, and human health. In doing so, they will play a central part in addressing the fundamental challenges posed by demographic change, scarcity of natural resources, sustainable mobility, and energy change (Wagner et al., 2017; Santos et al., 2017).

The revolution of embedded systems into IoTs, data, and services illustration have represented a vision of a global IoTs, data, and services through the evolutionary development of embedded systems as a result of building up network over the Internet. Closed embedded systems (e.g., airbags) perform the initial point. The next development level has two or more embedded systems which are networked, still within a closed system. The Acatech study agenda CPS is expanding the range to include global networking. For example, through using data from traffic jam alerts, those concerned can make the intelligent road junction. The next step represents through CPS creates Smart City using IoT, data, and Services (see Fig. 15.5) (Acatech, 2011; Bartodziej, 2017).

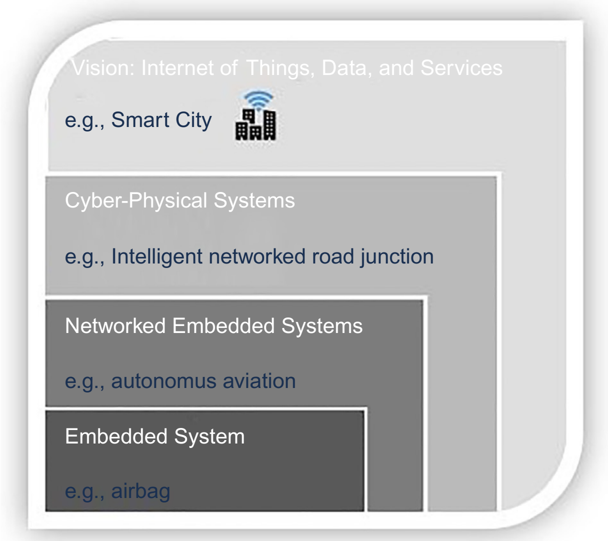

Fig. 15.5 The evolution of embedded system into the internet of things, data and service.

CPS communicates over the Internet and uses the service of Internet. They can be measuring and analyzing their environment (e.g., temperature, pressure, and movement) through sensors and then, from sensor data can assess the impressions. In order to effect a physical environment, they record data and use actuators (e.g., movement via grapplers, visual, or acoustic signals). Human and machine interfaces are used in order to communicate with CPS and manage them with voice or gesture control (Acatech, 2011).

According to Bauernhansl (2014), CPS base on autonomous and decentralized networks and optimize themselves within these networks. In an advanced stage, their individual skills are able to merge autonomously and hence can develop whole new abilities. The most sophisticated stage, they can create allocated virtual image to each object in the real-world IoTs. This data is exists in real time and is updated permanently. CPS enables the connecting together of three networks: humans-internet, the IoTs-the IoSs merge together to become one. Today, social networks help people to connect together. Furthermore, intelligent objects that join together in networks and use services to connect with one another have communication ability such as work pieces, vehicles, or machine.

Finally, it is envisaged that advances in physical cyber-mechanics will greatly enhance CPS in the near future, with improvements in functionality, reliability, usability, safety, adaptability, and autonomy.

15.3.2 Internet of Things and Services

IoTSs make it possible to create networks within the whole production process, which transform factories into a smart environment. CPS includes production facilities, warehousing systems, and smart machines that have been improved digitally and feature end-to-end ICT-based integration, from arrival logistics to production, marketing, outgoing logistics, and service. This does not merely permit production to be configured more resiliently but also utilizes the opportunities offered by even more differentiated management and control processes (Bartodziej, 2017).

In addition to optimizing currently IT-based processes, Industry 4.0 will release the potential of more differentiated tracking of both detailed processes and overall effects at a global scale that was previously recorded impossible to save. It also includes a closer collaboration providing new opportunities between business partners (e.g., supplies and customers) and workers to their mutual advantage at one and the same time.

IoTs do not just business tools but they can manage the business process more effectively and more productively. Moreover, they enable more comfortable a life space. In order to define the merging of the real world and virtual world of IT, they use by means of automatic identification technologies and real-time location systems, sensors, and actuators.

In recent years, the Internet of things have been available due to performed minor improvement and reducing cost for RFID (Radio Frequency Identification), sensors networks, NFC (Near Field Communication), wireless communication, technologies and applications. Finding of the physical status of things through sensors, together with collection and processing of detailed data, let instant response to change in the real world. This entirely interactive and responsive network yields awesome potential for citizens, consumers, and business.

RFID is increasingly becoming widespread such as factories, warehouses, and retail stores. Sensor technology is also indigenizing manufacturing and coordination in order to control processes and quality of goods. In traditional RFID applications, for example, access control and automation of production, tags moved in closed-loop processes, and RFID data are consumed in just a single client system. In these premises, there is no need of data exchange in organizational boundaries. In the same way that monolithic business information systems of the past have evolved into highly networked systems that use the Internet extensively, open-loop RFID applications in networked environments represent a challenge that various stakeholders from the industry face and partly solve.

Accessing real time information by means of ICT usage in the "anytime, anywhere" attitude, as offered by the paradigm of the IoTs, require clearing, scalable, secure, and standardized infrastructures that do not entirely exist today. These have been improved and continue to be developed, for example, in working groups within the EPC global community in order to collect user requirements and business cases to develop open global technical standards for improved visibility. Similarly, members of the open geospatial consortium (OGC) are constituting a framework of open standards for exploiting web-connected sensors and sensor systems of all types, including flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors, webcams, and satellite-borne earth-imaging devices.

The widespread adoption of the IoTs will take up time, but the timeline is gone ahead thanks to improvements in the underlying technologies. The sensors use anywhere at any time since the advances in wireless networking technology and the greater standardization of communications protocols. Ever-smaller silicon chips for this object are gaining new abilities, while costs, following the pattern of Moore's Law, are descending. Massive increases in storage and computing power, some of it appropriate via cloud computing, make number crunching possible at a very large scale and at a declining cost.

Briefly, none of this is news to the companies. But as these technologies mature, the range of corporate deployments will increase. Now is the time for executives across all industries to structure their thoughts about the potential impact and opportunities likely to appear on the IoTs.

> *Moore's Law: The global semiconductor industry has recorded impressive achievements since 1965, when Intel cofounder Gordon Moore published the observation that would become the industry's touchstone. Moore's law states that the number of transistors on integrated circuits doubles every two years, and for the past four decades it has set the pace for progress in the semiconductor industry. The positive by-products of the constant scaling down that Moore's law predicts include simultaneous cost declines, made possible by fitting more transistors per area onto silicon chips, and performance increases about speed, compactness, and power consumption. As a result, semiconductor-enabled products today play integral roles in every aspect of modern life (McKinsey & Company, 2013).*

15.3.3 Intelligent Objects

Considering the fact that CPS is intangible, theoretical, and yet abstract, technological concept that is based on the thought of Industry 4.0 forerunner can be improved and performed in several designs. The evolution of intelligent objects is perceived as already existing in a more practical context. Intelligent objects which are key to future Industry 4.0 scenarios have a high potential in order to the realization of end-to-end digital integration and subsequently for a paradigm shift in manufacturing. Acatech refers to the concept of objects in Industry 4.0 implementation recommendation. According to them, it determines an object of the physical or the virtual world, which adopts a certain position within a system. This fact is connected with the statements of Herzog and Schildhauer (2009) on the term object. While citing Alfred North Whitehead, the authors declare that an object sharply has to be distinguished from process concerning possible intelligence. The objects are entities identifying as related to events, which remain the same in the event flow. Although events occur and always convert into other events, this apprehension of intelligent objects, especially, is underlined by the theory of embodiment. The theory of embodiment has its origin in cognitive science, where Rodney Brooks developed it in the field of artificial intelligence around 1980. The central message of the theory is that the independent evolution of intelligence necessarily requires the existence of a body (object) that can interact with its environment and, consequently, generate knowledge by experiences. Intelligence, thus, is an expression of sensor motoric coordination that means that sensors (sensory organs) and actuators (motors, muscles) are coordinated by intern information processing procedures. Generally, the intelligence of an object can define according to its ability to perform information and data processing (Bartodziej, 2017).

The behavior of intelligent objects is highly dependent on where and how they are used. Through the intelligent objects, the everyday life of human action and the use of technical equipment changes in a way that can no longer be adequately covered by the classical vocabulary of instrumental action and technical functioning. Human actions are incorporated into larger contexts of technical functionality; technical operations gain greater autonomy within the context of action. Complex behavioral relationships arise from behavior, decision making and informing, and hybrid actions of human, machine, and medial authorities. In the following, some areas or "scenarios" are described from the essential fields of application of intelligent objects, whereby no claim to completeness is made. A real sample project is assigned to each scenario, mostly from the field of research funding.

Intelligent objects can process data and information. This ability can be either performed, centralized, or decentralized within intelligent objects itself. It can also be installed in a centralized structure such as a central computer. Based on this definition, the term intelligent object is misleading, as the (artificial) intelligence is only created through the interaction of the members of an intelligent object system. A geographic distribution of intelligent objects provides purely new functionalities within the interconnected systems.

15.3.4 Artificial Intelligence

Since the invention of computers and machines, their ability to fulfill various tasks is evolving day by day. Humans have developed the power of computer systems in terms of their various working domains, their increasing speed, and reducing size and weight with the lapse of time. Artificial intelligence (AI) is a branch of computer science that pursues creating computers or machines as intelligent as human beings. According to John McCarthy, it is "The science and engineering of making intelligent machines, especially intelligent computer programs." AI is through making computer, a computer-controlled robot, or a software that can think intelligently, in a manner similar to how intelligent humans think. AI is performed by studying how human mind thinks and how humans learn, work, and decide while trying to solve a problem, and then using the outcomes of this study as a basis of ongoing intelligent software and systems (Glockner et al., 2014; Bartodziej, 2017).

AI has two big goals of creating an expert system and implementing human intelligence to machines. The systems which show intelligent behavior, learn, prove, explain, and recommend its users as to behave like a human. Artificial intelligence is a science and technology based on multiple disciplines, for example, Computer Science, Biology, Psychology, Linguistics, Mathematics, and Engineering. A major spurt of AI is in the progression of computer functions along with human intelligence, for example, reasoning, learning, and problem solving.

Tech giants and digital native companies such as Amazon, Apple, Baidu, and Google are investing billions of dollars in various technologies known collectively as artificial intelligence. They see that the inputs needed to enable AI to finally live up to expectations of a powerful computer hardware, increasingly sophisticated algorithmic models, and a vast and fast-growing inventory of data are in place. Hence, AI is becoming a part of human life and their anticipation is in different fields such as the ones given below.

Gaming: AI plays a crucial role in strategic games, for example, chess, poker, etc., where the machine can think of an enormous number of positions based on heuristic knowledge.

Expert systems: There are some applications that integrate machine, software, and specific information to impart reasoning and recommendations. They give explanation and advice to the users, for example, Amazon's recommendation engine for users.

Natural language processing: It is possible to interact with the computer that understands the natural language spoken by humans.

Vision systems: This system can understand, comment, and apprehend visual input on the computer. AI has already achieved performance levels that surpass that of humans (e.g., in skin cancer diagnostics).

Speech recognition: Some intelligent systems are capable of hearing and understanding the language in terms of sentences and their meanings while a human talks to it, such as Apple's Siri.

Handwriting recognition: The handwriting recognition software reads the text written on paper by a pen or on screen by a stylus. It can get to know the shapes of the letters and turn it into arrangeable text.

Intelligent robots: They can implement the duties given by a human that have sensors to explore physical data from the real world, for example, light, heat, temperature, movement, sound, bump, and pressure. They have efficient processors, multiple sensors, and huge memory, to show intelligence. In addition, they are capable of learning from their mistakes and they can adapt to the unique environment.

Thanks to these enabling technologies, living space and manufacturing systems are easier manageable when the problems of today are considered (Tutorialspoint, 2015; Gilchrist, 2016).

15.3.5 Virtual Reality and AR

In this section, all digitally enabled disruptive technologies are defined that are likely to have an important impact on manufacturing within the next 10 years as Industry 4.0 is relevant. AR is real innovation disruptive technologies. The fact is that virtual reality (VR) and AR produce virtual environments as real-time simulations for product presentation and product-related explorations. These technologies partially integrate into the virtual environment of the user and product-related operations. AR functionalities provide the application of additional information and data into a VR environment (e.g., look-through functions or the accessibility of virtual control units). The real time of geometrics or functionalities promotes the consideration of procedures, in use tests, and product assessment. The ability to manipulate objects gives the virtual product a close real-life feeling. Furthermore, development-related duties, VR and AR technologies are used for applications in personnel training, maintenance, marketing, and education (see Fig. 15.6). One specific data format for these types of applications such as the virtual reality modeling language (VRML) was designed to exhibit 3D models and to integrate user-based interactions. VRML data that are generated from a 3D CAD expert model involve simplified geometry information without product history or structural data (Hirz et al., 2013; Gilchrist, 2016).

Experts also differentiate between AR and VR. VR is a completely computer-generated, immersive, and 3D environment that is displayed either on a computer screen or through special stereoscopic displays, such as the Oculus Rift. In contrast, AR (or mixed reality as it is also sometimes called) combines both the virtual and the real. Users of AR are still able to sense the real world around them; this is not possible when people are immersed in VR.

Consequently, VR and AR will play a part in the new manufacturing approach as components of business. While workers have been performing critical duty, their required knowledge or instructions

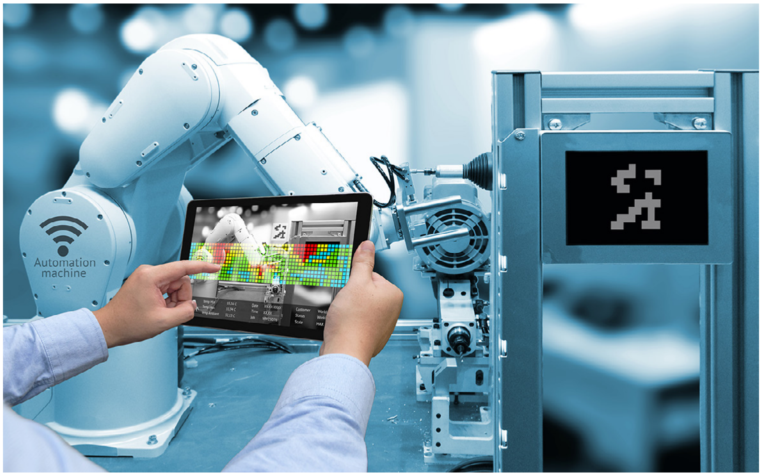

Fig. 15.6 Enabling technology: Augmented reality.

have been obtaining wearable devices to illustrate Google Glass that implements cameras and wireless connections to project information, on demand via eyeglasses. Other wearable technologies are also collecting steam, from intelligent textiles to wristwatch computers, which cannot only display e-mails and texts but also run mobile apps. Technologies needed in game consoles let us to use physical activities and gestures to interact with digital devices. With general virtualization applications, people will be able to work with robots without being exposed to any risk or danger.

15.3.6 3D Printer

3D printing creates physical products from the digital design file by joining or forming input substrate materials using the layer-upon-layer printing approach. Today's substrates use diverse materials ranging from plastic material to metals. The first step in 3D printing is to create an image using computer-aided design software; the second step is sending the image to a 3D printer. The last step is building the product by putting down thin layers of material. Through a 3D printer, the manufacturing sector has gained speed and creates custom-built designs that open doors to unlimited possibilities; complex products can be mass produced without high fixed-cost capital investments and a lower variable cost than traditional methods; production is closer to the point of demand with much less inventory, with unused powder being reused for successive printing, much less material is wasted.

Many sectors are benefit from this technology, for instance, the medical sector is viewed as being one that was an early adopter of 3D printing, further a sector with huge potential for growth, due to the customization capabilities of the technologies and the ability to increase lifetime as the processes improve and materials are developed that meet the medical grade standards. Another early adopter of rapid prototyping technologies, the earliest incarnation of 3D printing, was the automotive sector, especially many automotive companies at the preplan of motorsport and F1 races.

3D printing is emerging as a new way of preparing and presenting food. Initial forays into 3D printing food were with chocolate and sugar, and these developments have continued apace with specific 3D printers hitting the market. Some other early experiments with food include the 3D printing of meat at the cellular protein level. More recently, pasta is another food group that is being researched for 3D printing food (ATKearney, 2015; Gilchrist, 2016).

Eventually, 3D printer technologies are used in many sectors. Currently, consumer uptake is low due to the availability issues that exist at the entry level. They are going to take place more in the future.

15.4 Transition Process to Industry 4.0

The Industry 4.0 process is not as easy as it sounds. Currently, there are three design phases and a five-step approach that are helping plant operation managers tackle the challenges of connecting devices and making factories smarter. The Internet infrastructure such as connectivity, data to information conversion, and cybersecurity shift are crucial.

1. *Connectivity*: The Industry 4.0 is dependent on emitted and fluent connectivity between sensors, devices, and operational control software. In the case of factory automation, the software used is known as the manufacturing execution software (MES). In one's day, layers of industrial operation defined perspicuously and these layers were separated from each other. This implementation was beneficial for job definition; however, operational optimization and scalability were the disadvantages. Protocol division was a trouble. A line of computer numerical control (CNC) machines are required to be connected to the foundations' global control network because it would be complex, limited in functionally, and precious. Despite the fact that this is now leisurely changing, it is still very important to understand end devices, protocols, and physical interfaces in order to achieve perfect control from the plant floor to all virtual workstations. In short, connectivity is the first and most critical for Industry 4.0 technology.
2. *Data to information conversion*: Today's manufacturing sites are generating big data; such as in a beverage production factory, up to 12,000 devices can be connected to a single network. Sensors technologies have became integrated themselves increasingly, surpassing PLC barrier. After these nodes are connected, the challenge is processing data. Year after year, enterprise data companies using data clusters have approved to get the power of Big Data from the digital B2C space to industrial automation, but so far with limited success. This has been due to a lack of connectivity, the complexity of manufacturing facilities, and the massive amount of data produced in a typical manufacturing enterprise. Recently, industrial network bandwidth and the use of modulated edge computers have allowed factories to scale easily to meet the flow of data. Therefore, it is important to select a proper bandwidth. In addition, the manufacturing operation data requirements must also be met as they continue to grow over the coming years. The existing operators can quickly deploy intelligent solutions that enable localized real-time analytics bridging the communication gap between the factory floor local area network (LAN), the control LAN, and enterprise networks. Factory operators are beginning to realize that providing increased connectivity between the site/facility level and

the enterprise can provide significant benefits such as, according to a recent study on Industry 4.0, by McKinsey & Company a global mining company that has succeeded in transforming localized data collection into optimization measures for chemical processes that increase by 3.7%, about $20 million a year. Because of the huge amount of data that a network of meters can produce within a day, the transfer and storage of that data is often very difficult to facilitate in an industrial network. However, due to the upgradeability of embedded computers and industrial wireless networks and increased affordability, the processing and storage of stream data, large-scale manufacturing operations from large-scale production can easily record production data for many years and the central control room is real if any abnormality arises. The benefits of this data acquisition feature on the edge of industrial networks allowed the companies to extend their product life years and enlighten potential system failures before they arise. Small investments in industrial connectivity infrastructures have forced many accounting automation companies' accounting teams to rethink their application of the flat-line amortization model; every year an important point is dropped on this number and as a result, the value of shareholders is increased (Nuth, 2016; McKinsey & Company, 2016; Frost and Sullivan, 2017).

3. *Cybersecurity shift*: The cyber level of the industrial IoT movement is what basically distinguishes the industrial IoT from the IoT. In the industrial Internet, the cyber level serves as a central information transshipment center where data from all field assets and sensors are stored. It is at the cyber level where privatized analytics are carried out and widely reside for the purpose of allowing machines to connect in self-learning processes overtime. In simple terms, network data are being distributed among the various devices within the LAN, placing much of the bandwidth and file transfer burden of measurement and security evenly among the devices within the LAN. Bandwidth bottlenecks are reduced, as are potential areas of network fencelessness. Since the cyber level of the industrial IoT architecture, by its very nature, flips traditional cybersecurity and management models on their head by shifting traffic away from large corporate networks to a network of edge devices and workgroup subnetworks. In this model, each device has a role to play in the security of the greater network and the plant manager has the indispensability to construct the network with consideration to surplus, the strategic placement of firewalls, and the implementation of contingency plans in the event of network failures or network intrusions.

According to Frost & Sullivan, each country is different in terms of its level of readiness in adopting Industry 4.0. It has segmented Asia Pacific manufacturing countries into two: mature and emerging (see Table 15.1).

Table 15.1 Mature and Emerging Manufacturing Countries

Mature Manufacturing Countries	Emerging Manufacturing Countries
China	India
Japan	Thailand
South Korea	Vietnam
Taiwan	Malaysia
Singapore	Indonesia

Frost & Sullivan has examined the perception of Industry 4.0 by means of interactions between manufacturers with stakeholders across the region. While considering Industry 4.0 technology, they serve to give a perspective view into the awakening, areas of priority as well as challenges faced. As a result of the examinations made, the biggest problems faced by the producers are mentioned. These are both operational and business.

In all, 60% refer to operational problems over workforce problems like high revenue and skilled staff. In all, 40% refer to business as their biggest problems about the economic crisis and increased competition. Their exploration shows that operational problems still go on top of mind for manufacturers. Industry 4.0 solutions are well positioned to promote companies and help in operations. Another indicator of exploration is that 94% of manufacturers have not known the concept of Industry 4.0 and, therefore, there is a need for greater more in-depth awareness on functionality and value that Industry 4.0 brings. Considering where manufacturers are in Industry 4.0 application journey, the results are as follows:

In all, 12% of manufacturers having applicated an Industry 4.0 solution, 12% of manufacturers are planning proof of concept (POC) project in the next 12 months. In all, 64% refer to evaluating the technology for use in their own facility. In all, 12% of manufacturers do not have any plans (Table 15.2).

15.4.1 Reducing Implementation Risk With a Proof of Concept

POC project is documented evidence that a potential or service can be successful. Through POC, manufacturers can get over since it also provides the opportunity for an organization to solicit internal feedback about a promising product or service, while reducing

Table 15.2 Example Overview of Intelligent Objects

Scenarios	Real Project Examples
Health Care Service	
Artificial Body Organs	Retina Implantat
Personal Nutrition Consultant	NutriWear
Health Environment	PERSONA
Emergency Rescue	Med-onix
Dwell	
Networked Games	Fast Foot
e-Ticketing	Touch & Travel
House of The Future	InterOFFIS
Person Identification	e-Pass
Information Environment	Wireless Wolfsburg
Maintenance and Logistics	
Logistics networks	Intelligenter Container
Mobile assistance systems	SiWear

unnecessary risk and exposure and providing the opportunity for stakeholders to assess design choices early in the development cycle.

An increased volume of information existing provides the operators to better forecast and optimize their activities. Due to IoT, operational visibility is improved: from a historical view of information to a real-time one, and further to predictive analysis through remote monitoring providing three views of their operations (see Fig. 15.7).

Out of the myriad possible use cases, there are three possible choices for firm's first trial that can deliver quick return on investment (ROI) to their operations by leveraging data:

1. Optimization of operations by analyzing past operational data
   First steps include moving data in batches from hoary non-IoT inclined devices into the Industry 4.0 platform. Historical data can keep informed the operator's insight into the status of their machines. Through the agency of analytical method, tweaks can be made to improve efficiency and processes without investing to retrofit machines or install hardware at this point.
2. Real-time visibility through remote monitoring
   Second steps include installing sensors into machines and connecting equipment and lines. This enables remote monitoring and allows for real-time visibility of operational processes, as well across multiple locations, which permits for instant manifesto for problems and coordinated correction activities.

Fig. 15.7 Three stages of POC.

3. Predictive maintenance
Third steps include that performing analytics to this data will generate reports and dashboards for the predictive maintenance use case. Operational data are provided with historical records; preventive maintenance can be carried out on components with risk of failure.

15.4.2 Five-Step Approach to Successful Industry 4.0 Project

15.4.2.1 Business Objectives

Industry 4.0 project generally starts a result of operational managers trying to solve and improve their daily task on the production department. Feedback from manufacturers in China presents validation of these operational drivers. Hence, the first step of the approach includes identifying and understanding the operational bottleneck plant and line managers again and again face. What operational issues do Industry 4.0 address? Are there unique business objectives or client demands that require stringent measurements? Such as, clients like Unilever have compelled environmental and safety work standards on their contract manufacturers.

In shortly, operational bothers and bottlenecks are specified. These could be instigated by environmental or technical causes, or they could be process improvement demands specified by the executive management. Operational bottlenecks may be general issues or specific issues such as one legacy department could be as specific issue as convert to Ethernet or they could be as broad as lowering company-wide manufacturing costs by 5% within the next 3 years. For each case, presenting the bottleneck and challenges upfront makes an enormous difference for companies' connectivity provide.

> *For example: An operations manager for a machine building company deployed a plant-wide computer-integrated manufacturing (CIM) system many years ago. Now, the company has been obtained and its current processes must be integrated into the new company's operations that include the MES as well as the operational process control standards. The CIM system established is not meeting the current requirements and as a result performance is suffering.*
>
> *Changing the entire CIM operation is not an option, but the facility must be made more efficient and interoperable with the company-wide operational processes. The operations manager requires a brownfield solution that presented smart I/O condition monitoring that can help optimize their existing CIM and connect to the new MES.*

15.4.2.2 Prototype

The next step includes formulating a plan to display a trial proof of concepts project with a small budget. During the trial, the analysis aims at optimization through manual process improvement. The quantification of these gains is an important indicator that the research will be expanded to a wider extent (in the verification phase). The quantification of these gains is also a significant pointer (in the validation phase) of whether the trial should be widened upwards.

15.4.2.3 Validation

When a POC project is successfully working, the signs from the trial can be quantified and validated for management's confirmation. The data collected through sensors from the pilot devices can define areas of inefficiency or factors, which may lead to higher shortcoming. Managers are able to utilize this information for process improvements to reduce wastage. These process improvements should then be applicated on the production departments for another round of data collection.

15.4.2.4 Replication

After validation the data and checking the use cases, the proof of concepts can be considered a success when project objectives are met. Now that the system works for the pilot set of sensors and devices, the next step involves extending the setup to more machines and lines.

15.4.2.5 Global Rollout

This last step aims to obtain further efficiency and visibility through expanding Industry 4.0 connected systems outside the plant into the broader ecosystem.

15.5 Conclusion

Today's business management is based on two fundamental principles: effective resource utilization and productivity. It is not possible for businesses that fail to comply with these principles to be sustainable and competitive. In other words, lean and innovation is needed. In production areas, cycle time should be reduced, process steps that do not create value should be eliminated, energy consumption per unit product should be reduced, and innovation can be achieved through innovation.

To provide effectiveness and productivity in business, an important approach is innovation that occurs in the face of problems and needs. The emergence of unexpected events or the emergence of incompatibilities brings innovation to the ranks. In today's highly competitive business and manufacturing environment, the manufacturing industry is faced with the constant challenge of producing innovative products that have been reduced to the market. The increasing tendency of the globalizing production environment, design, installation planning, production planning, machining, assembly, and so on. Product development requires seamless task collaboration between these nodes as well as real-time information exchange between various nodes in the life cycle. In addition, increased environmental awareness and legislation have further constrained the removal of products, thereby encouraging product recycling, and maintenance and repair activities. Product development processes are becoming increasingly complex as products become more versatile and complex, become naturally complex, and product types multiply with mass customization tendencies. Thus, the manufacturing processes have to be more systematic in order to be efficient and economically competitive. The search for an innovative and effective solution to overcome these problems always improves the possibilities of the industry. The industry has seen four cycles. The first cycle is mechanization, the second one electricity, the third automation, and the fourth cycle is the Internet period. For manufacturing sectors, a new period has started at the Hannover Industry Fair in 2011. It was later developed by the German government. Indeed, Germany, the world leader in industrial automation, is an important example of measuring the impact of Industry 4.0. BCG reports that Industry 4.0 will create nearly 400 new jobs in Germany, a productivity increase of 3%–5% of the gross national income (GNP), an average increase of 1% in GNP, and a 10-year period is expected to trigger an investment of 250 billion euros in the process (Ong and Nee, 2004; Acatech, 2011).

In fact, it is not wrong to say that another important factor that triggers Industry 4.0 is the competition created by countries such as China and India. Developed countries such as Germany and the United States are aware of the fact that they must combine their traditional production models in their hands with their existing technological know-how in order not to catch up with countries such as China and India where the summit rises rapidly. With the Industry 4.0 revolution, the business world is entering a more digital, flexible, and connected turn. The most important feature of this trend can be summarized as the convergence of real and virtual mobility. In the next decade, many of the jobs done today are being told by intelligent machines that are in communication with one another, as robots will take over many of the workforce. Industry 4.0 shows that we have developed products, automobiles, electronics from machines, transforming every imaginable field, changing habits, reshaping objects, and objectives. Artificial intelligence, VR and AR, 3D printing, robots, and many other technologies would change the existing business models and would create new business areas. An organization's success in implementing this transformation depends on their cloud platforms and their ability to build a reliable connectivity infrastructure. If there is a need for air to breathe today, tomorrow will need to be able to do business and share important data with all of them (Kelker, 2011; Kagermann and Riemensberger, 2015).

As a result, as the physical and virtual world, the Internet, the massive data, and the advanced technology get closer to each other, the spaces of time and space begin to rise. The emancipation and flexibility of the way people do business also cause new models to emerge. At this point, the most efficient use of work discipline, personal responsibility, energy, talent, and creativity is more important than ever. And as far as technology is concerned, it is understood that the partnership is the most important value of the Industry 4.0 era. Because it is a new world order in which no one can exist without the other.

This period is customer focused. They can access everything very easily. It was not so easy to get information regarding a product was in the past. Now everything on the Internet can be followed. So, companies have to organize themselves accordingly and organize all sales channels and tools. If companies want to take part in a global competition, they must be in the transformation. In this transformation process, different parts of companies such as marketing and sales are intertwined with IT. This change will increase the efficiency of the foundations. When we look at the world today, China's production is seriously pushing the Western world. Cost differences are mentioned.

The way to close this gap is to increase productivity and to move to automation systems. Reduce costs and make a difference with technology and automation. For example, there is a 20%–25% cost difference between Germany and Chinese producers. If the industry is targeted with 4.0, reduce this gap to 5%, to make a difference with technology and automation. It will not be a big part of the current business after 15 years. Henry Ford has become more manageable by incorporating the entire plant into the workflow with the production band he uses. However, producers have to go out of the factory in this century and deal with both the consumers and the logistics part.

Over the next 5–10 years, the Industrial 4.0 revolution will completely change the design, production, operation, and service processes of products and production systems. Although the full transition to "Industry 4.0" lasts longer, critical developments will take place over the next 5–10 years and the winners and losers will be identified. In this process, the way to achieve this is through the competence of the systems, information technology, writing, data analysis, and investment in the workforce.

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