

Smart Factory: A Primer

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ABSTRACT

A smart factory is a highly digitized and connected production facility that relies on smart manufacturing. It can integrate data from system-wide physical, operational, and human assets to drive manufacturing, maintenance, and inventory tracking. This results in a more efficient, agile, responsive, proactive, and predictive system. This paper provides a brief introduction to smart factory.

Keywords: smart factory; Industry 4.0; factory of the future; digital factory; smart manufacturing; intelligent manufacturing

INTRODUCTION

Manufacturing is essential for realizing all future products and is an indispensable element of the innovation chain. While manufacturing may be regarded as a process that turns raw materials into physical products, the factory is the structure where manufacturing occurs. Traditional manufacturing companies currently face several challenges such as rapid technological changes, inventory problem, shortened innovation, short product life cycles, volatile demand, low prices, highly customized products, and ability to compete in the global markets. The manufacturing sector with the support of the government are working hard to secure their market share through inventions toward the fourth industrial revolution known as Industry 4.0, which was coined by German government in 2011 [1]. Industry 4.0 is enabled by the Internet and designed for improving the way modern factories operate through the use of the latest technologies. According to the architecture of Industry 4.0 shown in Figure 1, the product lifecycle covers the smart product design, smart production, smart manufacture, smart logistic, smart marketing, and smart maintenance and service [2].

Today, we are surrounded by many things that are called smart. For example, we have smartphone, smart homes, smart grids, smart city, smart energy, smart transportation, smart manufacturing, smart agriculture, smart living, smart environment, smart medication, smart materials, and smart factory. These technologies will ensure equity, fairness, and realize a better quality of life [3]. In traditional factories, the communication between a product and the different operators that act on the value chain is usually slow and inefficient. There is also lack of a whole traceability of the product. Smart systems, together with the Industry 4.0 paradigm, provide alternatives to tackle the issues [4]. The terms “smart factory,” “smart manufacturing,” “industry 4.0” and “factory of the future” represent keywords to denote what industrial production will look like in the future. They refer to a factory with a manufacturing solution that provides a flexible, adaptive, and efficient production. The smart factory refers to a leap forward from more traditional automation to a fully connected and flexible system.

A factory is made smart by communication technologies and the ability to use the data from connected operations. Being a smart factory also suggests an integration of shop floor decisions and insights with the rest of the supply chain. As shown in Figure 2, the smart factory is a move towards a factory-of-things, which is well aligned with the Internet of things [5].

ENABLING TECHNOLOGIES

The implementation of the smart factory is enabled by several technologies such as artificial intelligence, industrial robots, embedded systems, RFID, sensor networks, wireless connectivity, machine learning, big data, cloud computing, Cyber physical system (CPS), blockchain, and the Internet of things (IoT) or industrial Internet of things (IIoT). Thus, smart factory enabling technologies include:

- **Sensors:** Ubiquitous sensing technologies include radio frequency identification (RFID), auto ID, virtual reality, GPS, and Wi-Fi. A regular sensor can be converted into a ubiquitous sensor by connecting a networking module to it. The sensors (temperature, vibration, force, etc.) are used to monitor manufacturing processes.
- **RFID:** Manufacturing resources like machines, materials, and personnel are equipped with RFID devices and they become smart manufacturing objects. RFID technology enables real-time traceability, visibility, and interoperability in improving the performance of shop-floor planning, execution, and control of manufacturing systems.
- **Robots:** Industrial mobile robots are used in handling and transporting materials. This is appropriate for smart factory due to their flexibility and ability to communicate. Robots get the data from sensors and change their action accordingly. Robots with AI capability make it possible to involve the perception-based decision making which otherwise was not possible by rule-based algorithms in robots.
- **IoT:** There is huge potential for IoT and IIoT in smart factory. Major forces driving IoT in smart factory are

the growing need for centralized monitoring and predictive maintenance of manufacturing infrastructure.

SMART FACTORY CHARACTERISTICS

The structure of a smart factory can include a combination of production, information, and communication technologies. Central to the smart factory is the technology that makes data collection possible. These include the intelligent sensors, motors, and robotics. The defining features of a smart factory are: connectivity, autonomy, optimization, transparency, proactivity, and agility [6].

- **Connectivity:** Smart factories require the operations, processes, and materials to be connected to generate the data necessary to make real-time decisions. The entire factory system is connected with a network of sensors, switches, motors, etc. The connected production facility relies on smart manufacturing. Each facility is linked to the others and the entire enterprise both within the factory and beyond. Connectivity enables providing information at all industrial plant levels.
- **Autonomy:** Factory units are becoming more and more automated since it saves labor and material. The automation includes factory floors and robots working 24/7. Smart factories take this simple automation much further and are able to run without much human intervention. The Internet of things (IoT) standards (or the industrial IoT) will facilitate automation, allowing machines to communicate with machines in any sector. The connectivity and automation increase efficiency and productivity.
- **Optimization:** An optimized smart factory allows operations to be executed with minimal human intervention. Smart factory creates an environment where machinery and equipment can improve processes through automation and self-optimization.
- **Transparency:** A transparent network enables greater visibility and ensures that the organization can make more accurate decisions.
- **Proactivity:** In a proactive system, employees and systems can anticipate and act before problems arise. The ability of the smart factory to predict future outcomes can improve production, quality, and safety. The factory of tomorrow will be a proactive, responsive, and self-healing.
- **Agility:** Agile flexibility allows the smart factory to adapt to schedule and product changes with minimal intervention. The agility of future smart factories in terms of a continuous reconfiguration leads to dynamically changing traffic flows.
- **Singapore:** CS education has been adopted in Singapore before 2014, it is going to be mandatory starting from 2020. Some of the popular coding academy in Singapore include FirstCode Academy, Saturday Kids, Computhink Kids, SG Code Campus and Early Coders Academy etc.
- Others countries include Austria, Hungary, Denmark, France, Spain, Portugal and Bulgaria.

SMART FACTORY IMPLEMENTATION

The implementation of smart factory solutions makes sustainable production attainable which in turn tackles global challenges. The essential requirements for implementing the smart factory concept include the following [7]:

- **Interoperability:** It is important to communicate efficiently using IoT.
- **Virtualization:** It is essential in order to control physical processes by CPS and create a virtual copy of the physical world. Software-defined networking (SDN) and network virtualization can help to solve the challenges of future factory networking.
- **Decentralization:** It is required due to the soaring demand for customized products, which hinders central controlling and managing.
- **Real-Time Capability:** This concerns the need for collecting and analyzing information in real time.

BENEFITS AND CHALLENGES

A smart factory is an intelligent factory which is capable of improving competitiveness, productivity, quality, and customer satisfaction. With time, smart factories will only get smarter, faster, and more efficient. Other benefits include:

- The investment of constructing a smart factory benefits manufacturer by creating a safer and more reliable plant.
- Smart factories reduce dependence on human labor and the evolving roles of employees.
- Lower costs and an enhanced customer experience. Employees should be willing to keep on developing their skills.
- Real-time visibility creates the flexibility to mobilize the supply chain to meet peak demand.
- Although smart factories produce physical goods, they generate data and analytics as well, revealing the amounts of waste, usage of electricity and water.

Some of these benefits are illustrated in Figure 3 [8].

Key challenges concern robustness and business integration of the technologies involved is developing smart factories. Creating environmentally sustainable manufacturing is the key challenge for our future factory. The high interconnectivity of the smart factory makes the impacts of critical infrastructure breakdowns to be substantial. The idea of adopting a smart factory can appear complicated or insurmountable. By starting small with manageable components and slowly growing, the promise of the smart factory can become a reality. Some old factories cannot face challenges in keeping up with ever-shifting trends.

CONCLUSION

The smart factory is a manufacturing concept that provides efficient, flexible, and adaptive production solutions in a world of increasing complexity. Right now, the smart factory is regarded to be the factory of the future. The concept still needs development before fully reaching its practical application in an industrial production [9]. The necessary ingredients for creating the smart factory are already available. Smart factories make sense in a world that needs to balance. Companies that are slow to adopt smart factory technologies could be left behind. The future of manufacturing is with smart factory.

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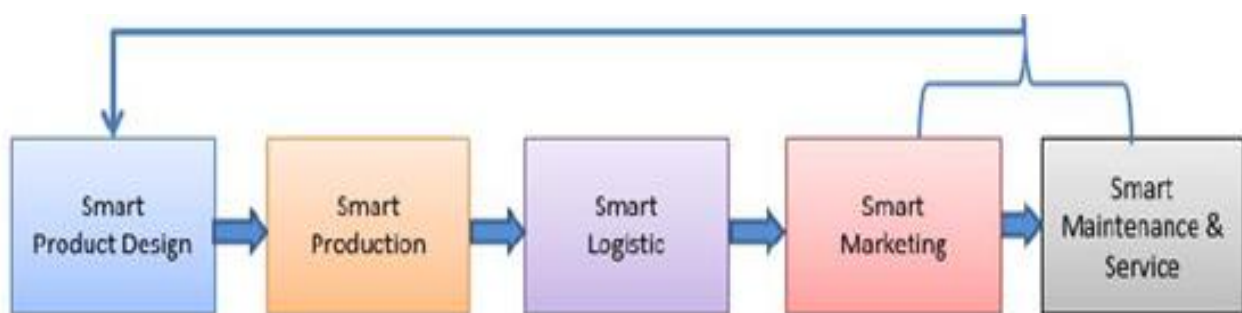


FIGURE 1: Product lifecycle in Industry 4.0 [2].

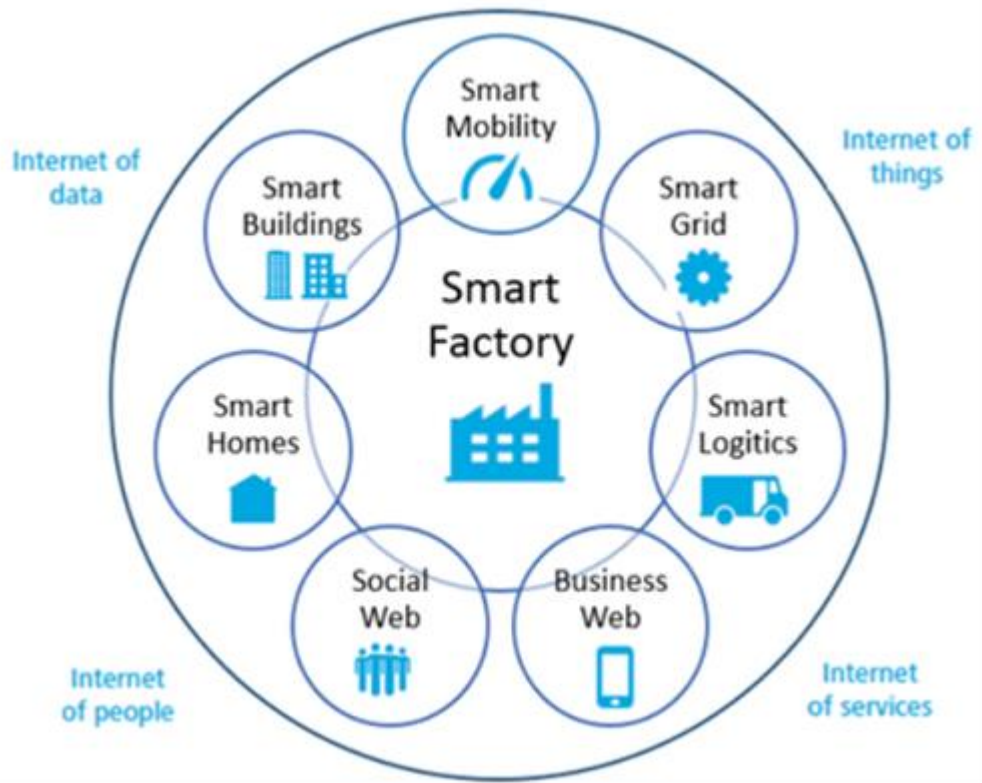


FIGURE 2: A typical smart factory [5].



FIGURE 3: Some benefits of smart factory [8].