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Planning and Scheduling

the Vital Industry 4.0 Transformation Component

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What is Industry 4.0

There is an increasingly rapid transformation in manufacturing and related industries. This transformation is enabled by people, processes, services and systems exchanging data in a connected environment [1]. It is driven by growing customer requirements and necessity on the part of companies to fulfill the dynamic and individualized customer demands. Cyber-physical systems (CPS), the Internet of things (IoT), cloud computing and cognitive computing are some of the key components of this transformation. This transformation is commonly referred to as the Fourth Industrial Revolution [2].

In 2011, the German strategic initiative “Industrie 4.0”, was started to establish Germany as a leader in advanced manufacturing solutions. It envisaged a shift to decentralized and smart production, where systems are capable of independently exchanging and responding to information to manage industrial production processes [3].

A historical perspective

The First Industrial Revolution began in the latter half of the 18th century. Over the next 75 years manufacturing transitioned from skilled artisan working manually to workers using water or steam powered machines. Starting mainly in textile industry, it extended to other areas like transportation and communication.

The phase of rapid industrialization in the final third of the 19th century and the beginning of the 20th century, is referred to as the Second Industrial Revolution. Unlike the first, which was characterized by new technologies, the second was about improving existing technologies and realizing synergies. Mass production, with the assembly lines and interchangeable parts were some of the improvements. The application of Taylor’s “Principles of

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Scientific Management" shifted the focus on organization of humans and machines, and training of the industrial workforce to increase productivity.

The Third Industrial Revolution, better known as the Digital Revolution, started in the latter half of the 20th century. Digital computers and the Internet brought about far reaching changes in communication technology. Automation, with CNC machines, Robots and PLCs in manufacturing, enabled very high levels quality and reliability coupled with higher productivity.

The Fourth Industrial Revolution

It is not easy to pinpoint where one phase ends and the next one begins. Now it is being felt that there are bigger gains in efficiency, flexibility and reliability by achieving a synergy between various existing systems using technologies, like Cyber Physical Systems (CPS), Big Data and Analytics, Computer Modeling, Cloud Computing, Mathematical Optimization.

Large amount of data related to industrial operations is collected using sensors. The history of operations can be accurately recorded, and the current state can be precisely determined. This information is used for analysis and decision support. Using Big Data and Analytics, and actuators, the autonomy of control and execution systems can be increased, thereby reducing human intervention, decreasing response time and increasing flexibility and reliability.

Complex digital models of industrial machines and man-machine systems running industrial processes are be built using advanced computer modeling software. These digital models are used for simulation and analysis, to gain a better understanding and insight into the behavior of the actual physical systems.

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The digital model, known as the "Digital Twin", can be continuously updated with data captured from multiple sources to represent its near real-time status of the physical system. [4] Using artificial intelligence, machine learning and analytics, the Digital Twin can learn from, from its own historical data or from other similar machines or from human experts. CPS integrates the dynamics of the physical processes with those of the software and networking, providing abstractions and modeling, design, and analysis techniques for the integrated whole [5].

Industry 4.0, Digital Twin, Cyber-Physical Systems and Smart Factory are closely linked concepts and have much in common. They have originated over the last 10 to 15 years, in different organizations. They are being investigated, researched and developed by even others to make the missing connections and fill in the gaps, to satisfy the demands of the industry. Like the Second Industrial Revolution, the Fourth Industrial Revolution too is about realizing the benefits of synergy.

Supporting Technologies

The on-going transformation leverages various technologies to bring about a convergence of Information Technology and Operational Technology to realize connected, decentralized and self-optimizing "smart" systems [1]. Several technologies are key to realizing the Factory of the Future. Some of them, like CPS, Big Data and Analytics, The Cloud, IoT, Computer Modeling have been already mentioned above. There are others that are also contributing to this revolution [6].

Autonomous Robots, Vehicles and Machines

Robots, vehicles and machines interacting with one another, and with humans and learning from them, to perform more and more complex operations with increasing autonomy.

Simulation

Simulations using real-time data and to mirror the physical world in a virtual model, are available to test and validate the parameters for succeeding operations.

Horizontal and Vertical Integration

Companies, departments, and machines, which earlier were 'silos', are now becoming more cohesive, enabling automated value chains. The integration is both horizontal - across the various production and business processes, and vertical - across various levels, i.e. Enterprise, Work Centers, Stations, Devices and Products.

Cybersecurity

With the increased connectivity arises the need to protect critical industrial systems from increased cyber threats.

Additive manufacturing

Additive-manufacturing methods are used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs.

Augmented reality

Augmented-reality-based systems support a variety of services, providing workers with real-time information to improve decision making and simplify work procedures and to make them safer.

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Design Principles

Though there is a common understanding of Industry 4.0, it lacks a clear definition. However, there are certain principles that guide the development and implementation of solutions [7].

Interoperability

The ability of CPS and people to communicate with each other through the IoT.

Virtualization

The ability of virtual models to use real time sensor data, aka information transparency.

Service orientation / Technical assistance

The services of CPS and humans are available as a service and can be utilized by other entities. This includes ability of systems & CPS to support humans in decision making and physically support humans in conducting unpleasant, exhausting, or unsafe tasks.

Decentralization

The ability of CPS to make certain decisions and to perform tasks autonomously. Other decisions are delegated to higher level CPS or human systems.

Real-time capability

Data needs to be collected in real time. It has to be analyzed and optimal decisions are necessary in 'near-real-time'.

Modularity

This provides the flexibility to adapt to changing requirements by adding, removing or replacing individual modules.

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Benefits

These concepts and technologies are evolving in response to the customer demands. Therefore, satisfying these demands is by itself the biggest over-riding benefit. Besides, there are many other cascading benefits to the entire supply chain.

Enhanced productivity through automation

Automation reduces errors and delays, speeding up production and reducing waste. It improves reliability of output, benefiting the immediate neighbors in the supply chain..

Optimization in a digital supply chain

With CPS being networked, sharing information, optimization can be carried out across individual entities in the supply chain, extending the optimization from a local level to a global level. It enables the best possible combination of operation, tools and parameter settings, for the given conditions and constraints.

Real time data for prediction and optimization

Data analytics is used to predict machine and system behavior. This enables prevention of or preparation for critical events before they occur, allowing optimal use of allied services and resources.

Data and analytics for optimization

At present optimal utilization of resources and materials is achieved by planning offline. The plan is rendered sub-optimal due to changed conditions when the plan is operationalized. With real time data and analytics, plan can be optimized for near real time conditions.

Safer working and sustainable work environment

Real-time monitoring of working conditions allows prediction, quick detection and enhanced protection. Remote operational control provides enhanced ergonomics and safe work environment.

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About Optessa

Optessa is a leader in intelligent planning, sequencing, and scheduling optimization software with many successful implementations among top tier global manufacturers.

Optessa products have wide applicability in industries as diverse as auto OEMs, suppliers, power equipment, electronics, semiconductor, and mills; batch process industries such as food and beverage, and paints; as well as shipping and logistics. The company has offices in Edmonton, Alberta, Canada; Hazlet, New Jersey, USA; and Goa, India. Optessa's leadership team combines deep expertise in software, mathematics, manufacturing, and optimization technologies with unmatched customer commitment.

Optessa supports global deployment at more than 100 distinct manufacturing facilities and production areas. We also partner with industry leaders, Deloitte and Tech Mahindra, to further enhance our client support.

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