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Industry 4.0: The Future of Smart Factories

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Abstract: Industry 4.0 is a modern approach to enable communication between people, products and complex systems by using internet technology with control systems. Smart sensors and actuators are used for enabling communication and improving intelligent operation control as a result of which the products and production tools with embedded systems are improved. These are called cyber-physical systems pose a challenge in design and development processes. Therefore relevant engineering approaches are required. A state-of-the-art for Industry 4.0 is presented here and the main cases are reported for establishing this framework. When Industry 4.0 is referred, safety, security, knowledge protection and privacy play a key role.
Keywords: Industry 4.0; Cyber-Physical Systems; Enterprise-Resource Planning; Manufacturing Execution System; Internet of Things

I. INTRODUCTION

Industrial production is now led by production advancements and global competition in adapting to newer technology. Industry 4.0 is a promising approach for industrial manufacturing processes and integration of business into factor models. Suppliers and customers can be brought under a single value chain under this model.

Technical aspects of these requirements are addressed by the application of the generic concepts of Cyber-Physical Systems (CPS) and industrial Internet of Things (IoT) to the industrial production systems. Therefore the CPS building blocks form the bass for the Industry 4.0 execution system.

Embedded control systems with decentralized control and advanced connectivity form some of these blocks. These blocks aid in identifying, locating, tracking, monitoring and optimizing the production processes.

Also, ample use of software support is essential for execution of Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP). This will help in integrating of business and manufacturing processes.

The third important aspect is handling of a big amount of data collected from the processes, machines and products. Typically the data is stored in a cloud storage.

This data requires extensive analytics that lead from the ‗raw' data to the useful information and, finally to the concrete actions that support an adaptive and continuously self optimizing industrial production process.

Due to the importance of this transition for the position of a country in a global market, some government-led initiatives were introduced all around the globe to aid transition from traditional industrial operation.

Germany was the first country to introduce Industry 4.0 as a concept and implement it in full cycle in their factories. General Electric in North America also mentioned this topic in their conference in 2012.

It is seen as a tight integration of real and digital worlds that combines big data analytics with the Internet of Things.

The concept assumes a much broader application area as the Industry 4.0 and covers power generation and distribution, healthcare, manufacturing, public sector, transportation and mining [1].

Industrial Internet Consortium was set up by General Electric and other related companies to benefit from the advances in the field of Internet and make use of it in Industrial Automation. With this improvement, 46% of the global economy can be increased is estimated by the consortium.

II. MOTIVATION

The point is to create value for customers, and that means to involve them in the process from the beginning. Of course, the companies that use the highly efficient mass production to achieve economies of scale are in benefit, while at the same time they have the opportunity to offer a high level of adaptation. Industry 4.0 objectives are achieved by embedding latest technology into manufacturing processes.

The technologies have moved forward from being a mere account management like payment transaction and businesses and applications and different versions of software. The olden days of using different layers of business to maintain and manage are gone. ERP is being slowly being replaced by factories because it adds to the administrative load and in interferes in manufacturing processes making them slower

III. OBJECTIVE

The key objective of Industry 4.0 is to lead the manufacturing ahead: to be faster, more efficient, and customer-centric while pushing beyond automation and optimization to discover new business opportunities and models. The other critical area where technology makes a big impact is with your workforce.

Communication and collaboration are what will help you retain your best people. Employees need to be communicated with what is happening in the manufacturing at the moment and to search for suitable solutions that work. It also means that companies should strive to retain quality candidates and make them adapt to modern technology. The days of cubicles, tethered desktop computers, and physically being present on the shop floor are gone. Young workers want to run everything including business from mobile devices.

IV. BACKGROUND.

That the Industry 4.0 concept comes from Germany is not surprising, since Germany has one of the most competitive manufacturing industries in the world and is even a global leader in the sector of manufacturing equipment. Industry 4.0 is a strategic initiative of the German government that traditionally heavily supports development of the industrial sector.

Germany's influence in Industry 4.0 plays an important role in bringing up the machinery and automotive manufacturing over the whole world. The fundamental concept was first introduced at the Hannover Messe in the 2011. Since its introduction, Industry 4.0 is in Germany a common discussion topic in research, academic and industry communities at many different occasions. The important point is to extract the capacity of new technologies and concepts. Availability and usage of Internet technology and IoT. Amalgamation of technical and business processes in factories. Digital association with virtualization of the physical world.

The term "Smart Factory" means to include smarter means of industrial production to improve and enhance the smart products. Apart from the obvious consequence of digitalization and latest technologies, the concept of Industry 4.0 also helps in exploiting newer ways to increase profits in industrial automation. For example, the cost of production were reduced with the start of just-in-time production, by adopting newer concepts of lean production and by outsourcing production to regions where costs are very less. In this regard, Industry 4.0 is a promising answer to decrease costs of production.

According to some sources, Industry 4.0 factory could result in decrease of [4]: production costs by 10-30%, logistic costs by 10-30%, quality management costs by 10-20% .

V. NEED FOR INDUSTRY 4.0

The process of industrial and technological advancement is continuous but momentary. New technologies replace old ones, as the market demands for better and faster results. Traditional production, logistic, and manufacturing processes work well for most companies now, but the near future demands more intelligence and flexibility in technologies. Industry 4.0 is referred to as smart factory and rightly so.

A. Here Are a few Reasons that Emphasize the relevance of Industry 4.0 in The Current Times

1) *Attenuates manufactural challenges :* Markets are volatile; products have short life cycles and get more complex each day. Industry 4.0 aims at easing these challenges by guiding companies on how to use data from production, service, and social media for quicker results, simultaneously enable them to react faster to demand changes and to implement new configurations.
2) *Boosts innovation :* Digitization of industry 4.0 will speed up the implementation of business models and strategies by predictive maintenance or business forecasting, and increase efficiency.
3) *Is customer oriented:* Industry 4.0 will assist in fulfilling consumer demands for "smart" products. By easing the process of crowdsourcing it will lead to a faster design and manufacturing process, satisfying individual-to-individual consumer demands
4) *Speeds production :* Industry 4.0 will aid manual workers in managing complex situations, solving urgent problems, and ensuring smooth production.

VI. DESIGN PRINCIPLES

Industry 4.0 is based on key six design principles. These principles will support companies in identifying and implementing Industry 4.0 scenarios. They are :

A. Interoperability
B. Virtualization
C. Decentralization

D. Real-Time Capability
E. Service Orientation
F. Modularity
G. Human-Machine Interaction
H. Connectivity

VII. COMPONENTS

A. Cyber Physical Systems

The theory of computation and the theory of dynamic systems combine to form the Cyber Physical Systems. This may mean in 2 approaches :

1) *Cyberizing the physical:* Computation techniques to build abstraction and interfaces will lead to equip physical subsystems with artificial intelligence. For example through embedded systems and AI Moreover correspondence turns into an essential component to interface with both, other digital physical frameworks and in addition to human
2) *Physicalizing the cyber:* Physicalizing the digital communicates deliberations of dynamic frameworks to programming and interfaces and arrange parts to speak to their dynamic conduct in time. CPS are a amalgamation of embedded systems, actuators and sensors, and internet equipments and their configuration. Figure shows a configuration approach that creates CPS and its application in production systems.

Network access is provided by supplying embedded systems with an Internet Protocol supported configuration like IP address

B. Internet of Things

The combination of the Internet of Things (IoT) and the Internet of Services (IoS) in the manufacturing process has begun the fourth industrial revolution. The IoT allows "things' and "objects', such as sensors, RFID, actuators, cell phones, which, through unique addressing schemas, communicate with each other and cooperate with their neighboring ‗smart' components, to reach common goals. Here, "things" and "Objects" are components of a typical Cyber Physical System.Therefore, the IoT can be defined as a network in which CPS cooperate with each other through unique addressing schemas.

Application examples of the IoT are Smart Factories, Smart Homes, and Smart Grids. The internet of things comprises communicating smart systems using IP addresses. The latest IPv6 (internet protocol version 6) gives an IP address space of 128 bits which enables to define 2^128 individual addresses or 3.4*10^38 addresses.

By this each and every physical object on the network can be addressed by a unique IP address and can be communicated by any other object on the network.

VIII. SMART FACTORY

"Smart factories" constitute an important feature of Industry 4.0‖. A smart factory can be defined as a model that assists people and machines in a context-aware framework. This is guaranteed by systems working in background, so-called 'Calm-systems' and the system can make context information like the position and status of an object. This way it can be called as context-aware. Information from real and virtual world are collected to get the task done successfully.

Real world data like position of an object or some tool measurement can be mapped to virtual world data drawing, electrical circuits and software simulation models. Calm systems are the hardware in a typical smart factory.

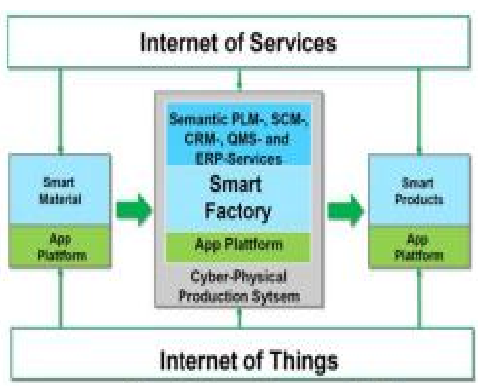

Fig.1 : Smart Factory

The ability to communicate and interact with its environment is the main difference between calm and other systems in a smart factory. On the basis of the meanings of CPS and IoT, the Smart Factory can be defined as a factory where CPS interacts with the IoT and helps people and machines in the execution of the tasks.

For example, a smart factory in WITTENSTEIN Bastian‘ production facility in Fellbach, Germany is organized with respect to pinciples of lean production. Intelligent workpiece carriers were used for reporting when a work piece is ready to be picked up and allowed to initiate the milk run only if there is a demand. This helps decrease the number of milk runs and relieve labourers from un-necessary work.

IX. CONCLUSION

On the hindsight, glancing at previous revolutionary development of manufacturing from its beginning until today, we can observe that the time between these revolutions eventually reduced and that rapid steps we are walking into the future. The upsurgeance of the Internet and Internet technologies of recent times undoubtedly made a big progress in all man made activities. It is inevitable integration in production systems, which will further affect the increase in the complexity of the existing production systems, as well as new systems coming to us, such as cyber – physical production systems.

The development of production systems in the spirit of cyber– physical production systems, use of digitization and e - business imperative is to aspire to smart factories of the future. Machines take up the human role in factories. But still the human integration is inevitable with a digital, electronic, virtual world, so that our work is preceded by further development of production systems in terms of reliability, efficiency, safety, etc. Moreover correspondence turns into a vital element to interface with both, other digital physical frameworks and in addition human.

Physicalizing the digital: Physicalizing the digital communicates deliberations of dynamic frameworks to programming and interfaces and additionally The present and future advancement is portrayed by significant and fast logical what's more, mechanical changes, which result with reindustrialization existing ventures and the renewal of an extensive variety of human exercises and open capacities in private life. Innovative improvement, as the most vital factor and an imperative essential of general improvement surmises the advancement and utilization of new advances and forces the requirement for rebuilding of existing, and in addition planning new plants with new settings (fractal, virtual production line).

Therefore, the necessary rapid and immediate change in the existing situation is needed, and it must include:

A. General support in defining a development strategies and policies of its realization, -Strategically oriented factors, research institutions and supporting institutions.

B. Industrial organized development of new scientific knowledge and their direct transfer into the economy of the region. Simultaneous changes are possible only on the basis of unique development strategy in which an important place should take the establishment of regional, especially innovation networks of smart factory, which should be the generator of new products, services and job creation.

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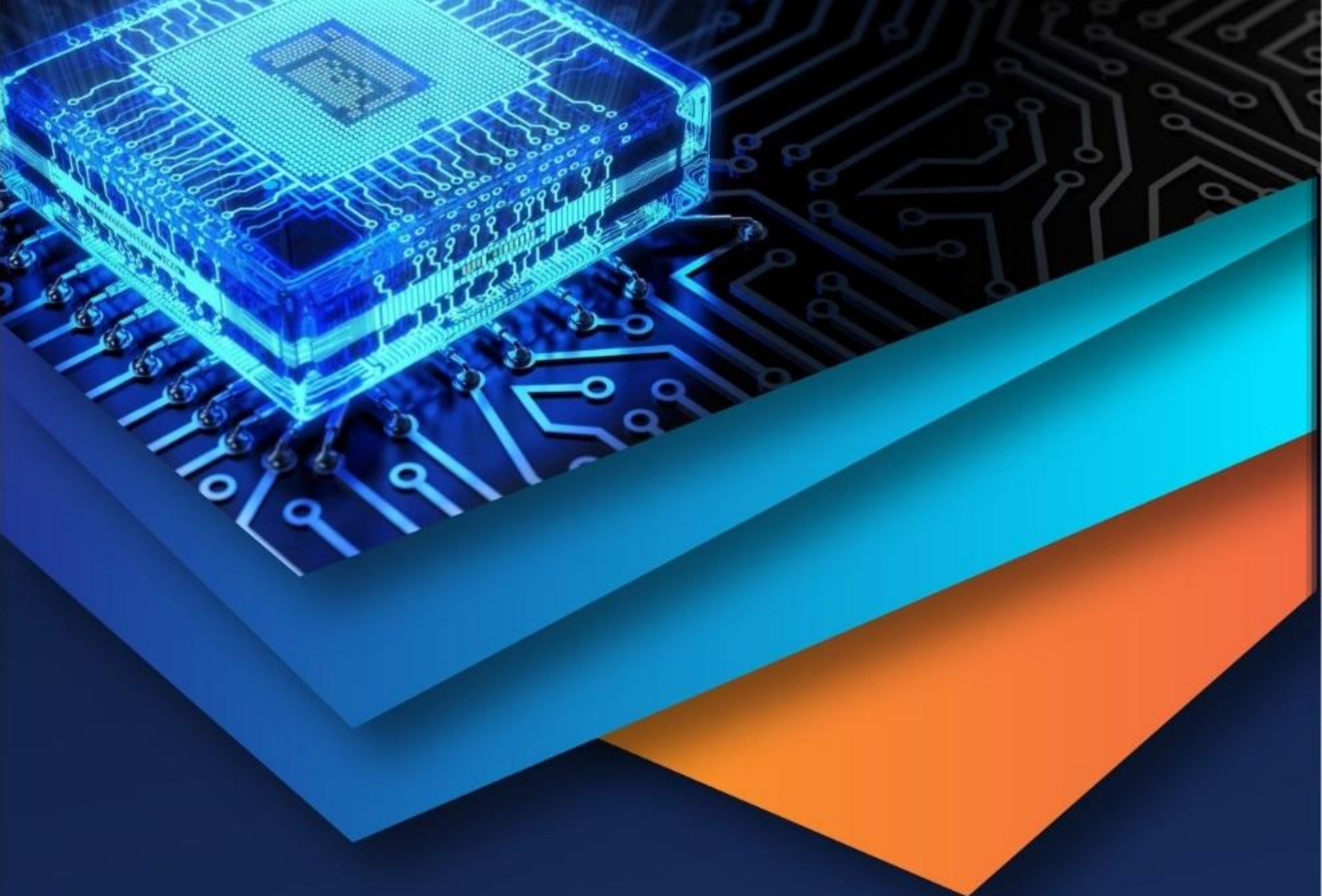

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