A SUCCINCT STUDY AND ANALYSIS OF SMART MANUFACTURING: IOT IS DRIVING THE NEXT INDUSTRIAL REVOLUTION

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Abstract: Cultivating contest among manufacturing businesses and the advent of the Industry 4.0 is the digital transformation of industrial markets with smart manufacturing currently on the forefront. Smart manufacturing allows factory managers to automatically collect and analyze data to make better-informed decisions and optimize production. The data from sensors and machines is communicated to the Cloud by IoT connectivity solutions deployed in the factory. That data is analyzed and combined with contextual information and then shared with authorized stakeholders. IoT technology, leveraging both wired and wireless connectivity, enables this flow of data, providing the ability to remotely monitor and manage processes and change production plans quickly, in real time when needed. It greatly improves outcomes of manufacturing reducing waste, speeding production and improving yield and the quality of goods produced. In this cram, Industry 4.0 can provide manufacturers many benefits such as improved efficiency, lower costs, higher revenues, and increased innovation. Industry 4.0 changes the basis of competition in manufacturing Cost, quality and speed were seen as tradeoffs.

***IndexTerms - Industry 4.0, smart manufacturing, Artificial Intelligence (AI), machine learning, and Virtual Reality (VR), IoT* Technology**

I. INTRODUCTION

Industry 4.0, a German strategic initiative, is aimed at creating intelligent factories where manufacturing technologies are upgraded and transformed by cyber-physical systems (CPSs), the Internet of Things (IoT), and cloud computing [1, 2]. In the Industry 4.0 era, manufacturing systems are able to monitor physical processes, create a so-called "digital twin" (or "cyber twin") of the physical world, and make smart decisions through real-time communication and cooperation with humans, machines, sensors, and so forth [3].Industry 4.0 combines embedded production system technologies with intelligent production processes to pave the way for a new technological age that will fundamentally transform industry value chains, production value chains, and business models. In the context of Industry 4.0, manufacturing systems are updated to an intelligent level. Intelligent manufacturing takes advantage of advanced information and manufacturing technologies to achieve flexible, smart, and reconfigurable manufacturing processes in order to address a dynamic and global market [4]. It enables all physical processes and information flows to be available when and where they are needed across holistic manufacturing supply chains, multiple industries, small and medium-sized enterprises (SMEs), and large companies [5, 6]. Intelligent manufacturing requires certain underpinning technologies in order to enable devices or machines to vary their behaviors in response to different situations and re-quirements based on past experiences and learning capacities [7].These technologies enable direct communication with manufacturing systems, thereby allowing problems to be solved and adaptive decisions to be made in a timely fashion. Some technologies also have artificial intelligence (AI), which allows manufacturing systems.

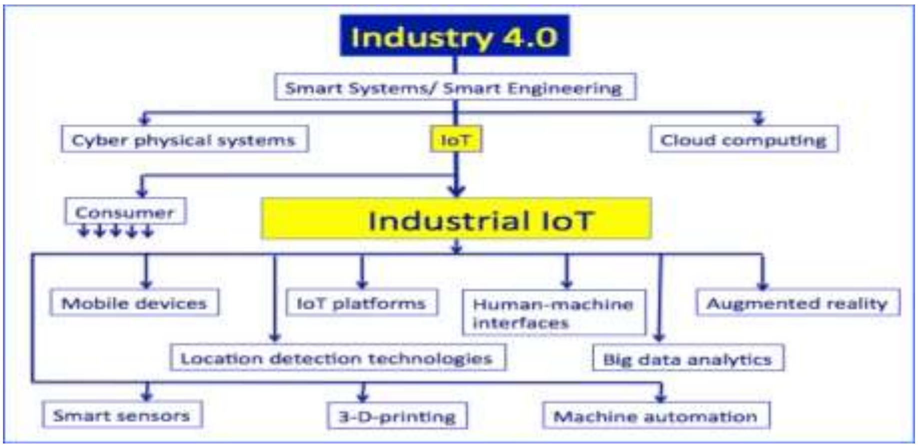

Fig 1: Digital Transformation, Industry4.0 and the Internet of Things

Thereby allowing problems to be solved and adaptive decisions to be made in a timely fashion. Some technologies also have artificial intelligence (AI), which allows manufacturing systems to learn from experiences in order to ultimately realize a connected, intelligent, and ubiquitous industrial practice.

II. KEY INDUSTRY 4.0 TECHNOLOGIES

New Industry 4.0 technologies, spanning mobile computing to cloud computing, have undergone vast development in the last decade and are now ready to be used as commercially available, interconnected systems within manufacturing – this is Industry 4.0. It holds the key to accessing real-time results and data that will catapult the industry into new levels of lean achievements. The concept of Industry 4.0 however, is not a simple one. It envelops many technologies and is used in a variety of different contexts. There are five pieces that define Industry 4.0 at its core. Each piece is similar in nature but, when integrated together, create capability that has never before been possible. In an effort to understand Industry 4.0, the following five terms are explained as they contribute to the next industrial revolution:

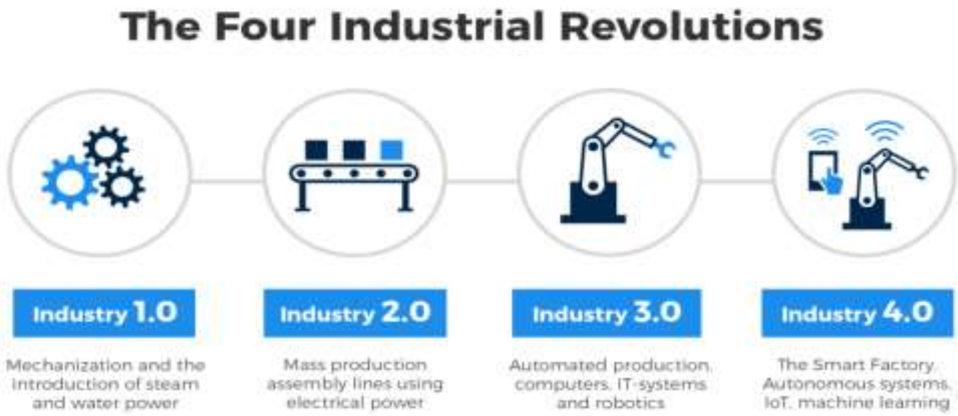

Fig 2: Industry 4.0 and how smart sensors make the difference

2.1 BIG DATA

As per Forbes, Big Data is a collection of data from traditional and digital sources inside and outside your company that represents a source for ongoing discovery and analysis. Today data is collected everywhere, from systems and sensors to mobile devices. The challenge is that the industry is still in the process of developing methods to best interpret data. It's the evolution of Industry 4.0 that will change the way organizations and solutions within those organizations work together; teams will be able to make better, smarter decisions.

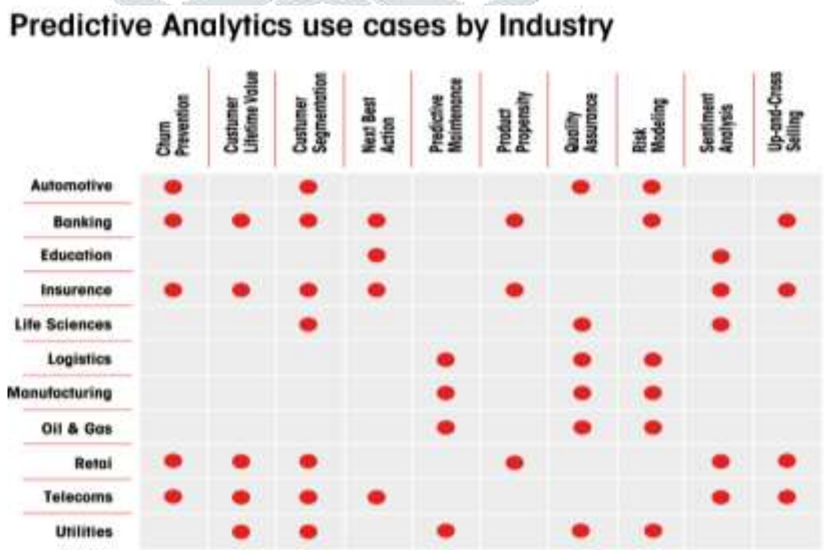

Fig 3: Big Data: Long Live Predictive Analysis

2.2 SMART FACTORY

The concept of Smart Factory is the seamless connection of individual production steps, from planning stages to actuators in the field. In the near future, machinery and equipment will be able to improve processes through self-optimization; systems will autonomously adapt to the traffic profile and network environment. Leading by example is the Siemens Electronic Works facility in Amberg, Germany. Smart machines coordinate production and global distribution or a built-to-order process involving roughly 1.6 billion components. When the Smart Factory is achieved, it will represent a pivotal shift for Industry 4.0, as the revolution will begin to roll out across multiple verticals. Various markets spanning healthcare to consumer goods will adapt Industry 4.0 technologies initially modelled in the Smart Factory.

Fig 4: Smart Factory Automation

2.3. CYBER PHYSICAL SYSTEMS

Cyber physical systems are integrations of computation, networking and physical processes. Computers and networks monitor and control physical processes with feedback loops; the physical system reacts; the system uses software to interpret action and tracks results. The notion centers on computers and software being embedded in devices where the first use is not computation; rather it is a loop of action and machine learning.

Fig 5: Industrial 4.0 Cyber Physical Systems concept. Big data, cloud computing, cps, smart logistic, augmented reality, smart building, automatic robotics, smart g.

2.4 INTERNET OF THINGS (IoT)

The internet of things is a simple term for a grandiose concept. IoT is the connection of all devices to the internet and each other. As Wired said, “it’s built on cloud computing and networks of data-gather sensors; it’s mobile, virtual, and instantaneous connection.” This interconnection will enable “smart factories” to take shape as equipment will use data to manufacture, move, report and learn at astounding rates, efficiently. Click here to learn how the industrial IoT drives productivity in factories.

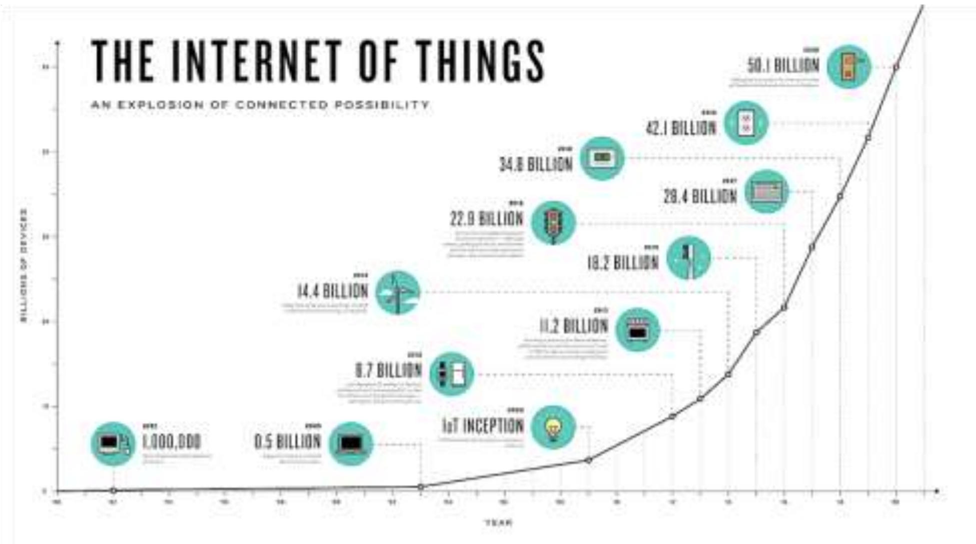

Fig 5: Internet of Things (IoT)

2.5 ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

The information delivered by sensors and IoT-driven systems is too vast for humans to reasonably analyze. AI and machine learning algorithms can contextualize the data and flag anomalies or make recommendations."[AI and machine learning] can help detect early warning signals of assets [becoming] unhealthy," said Derick Jose, co-founder and chief data scientist at Flutura Decision Sciences and Analytics. "For example, top-drive RPM temperature anomalies could be [the] signature of an impending breakdown. “Moreover, AI serves to improve efficiency in the overall operation, Jose said. By quickly returning predictions on the impact of minor changes, decision-makers can understand the effects before they implement something new.AI is specifically useful when it comes to digesting the massive flows of information captured by sensors and IoT-enabled devices. Those vast troves of data would be nearly impossible for a human operator to contextualize, so allowing computers to do it actually makes that captured data valuable.

Fig 5: Industry 4.0. Artificial intelligence automation of product manufacturing on smart factory.

2.6 MIXED REALITY

Mixed reality is also a major component of Industry 4.0. Big companies are already issuing mixed reality devices like helmets and glasses to employees in hopes that the increased communication and visualization of contextualized data will boost productivity and intelligent decision-making. “Mixed reality is a real game-changer in manufacturing," TimLynch, CEO of Psychsoftpc, said. "For repair personnel, it allows them to 'see inside' the machine that needs repair or 'see through walls' to the cables and pipes behind to know exactly where to drill or cut. “Couple those capabilities with the predictive maintenance enabled by IoT and AI, and you've got a recipe for high-tech success. If the data suggests a machine are overheating, for example, and the machine-learning algorithms flag it is anomalous enough to warrant dispatching maintenance, workers can employ mixed reality to determine whether a machine is beginning to overheat and precisely which components are affected. To take it a step further, imagine the maintenance person diagnosing the affected machine recognizes a problem but doesn't have the expertise to fix it. Mixed reality devices can connect someone with the proper expertise to the person on-site, who can then show them step by step, through digital overlays, how to perform the repairs. For training purposes, mixed reality creates an environment where employees can experience virtual situations relevant to their job without risking actual equipment or manufacturing uptime."In training, workers can practice on virtual products to gain experience that will carry over to the real world," Lynch said. "They can be put in simulated situations that they could face in doing their job and learn how to handle them virtually before being exposed to them at work."

Fig 6: Mixed Reality

2.7 3D PRINTING

3D printers have existed since 1983, though were often only in the hands of large companies. Back then, the term was "rapid prototyping," and they certainly continue to do that today. But it's not just prototypes anymore; 3D printers are also employed in low-volume manufacturing, perhaps to test products or bring samples to trade shows. “When small companies develop new products and need to make 50 parts to test, or just to bring to a trade show, tooling up for traditional manufacturing can be very expensive," Doug Collins, owner of Avid 3D Printing, said. "They might not have the capital to tackle [traditional manufacturing]. 3D printers allow low-volume production without as much investment so they can save that capital for the other important stuff, like marketing. “As the technology continues to improve, it's more common to find 3D printed parts within larger projects. One example is GE Aviation's 3D printed fuel nozzle, which is part of the CFM LEAP airplane engine. By printing certain components, manufacturers can save time and money to create the same final product.

Fig 7: 3D Printing in Automotive Industry

III. BENEFITS

The majority of manufacturers are ready to change their business because they see definite benefits in industrial IoT and smart manufacturing.

- **Improved employee productivity:** Using real-time data from sensors allows employees to monitor and improve processes efficiently without delays, which enhances productivity.
- **Asset optimization:** Sensors track assets (machinery, equipment, tools, trucks, etc.) in real-time, providing visibility of their potential. On the basis of this data, businesses can make quick decisions and optimize their asset usage at maximum capacity.
- **Reduction of operating costs:** Intelligent machines and data analytics lead to reduced consumption of fuel and electricity, cuts inefficiencies and decreases overall expenses.
- **Improved quality of goods**: Automation eliminates the human error , and companies are able to produce higher quality goods.

IV. FUTURE OF MANUFACTURING WITH IoT

Manufacturing industries intent to tap the potential benefits of IoT to drive considerable cost savings by enhancing process efficiency, improving asset utilization and boosting productivity. Manufacturing industries are embracing IoT as IoT driven innovations are expected to open up additional sources of revenue from new business models and opportunities by increasing return on R&D investments and capture competition by reducing time to market. In a 2012 survey by Forrester and Zebra consulting only 15% of organizations had an IoT solution, and 53% had plans to implement in the next two years. According to Cigniti Technologies, manufacturing will be the sector most affected by IIoT, gaining $3.9 trillion.In general, the implementation of IoT for smart manufacturing is one of the key goals for numerous enterprises.

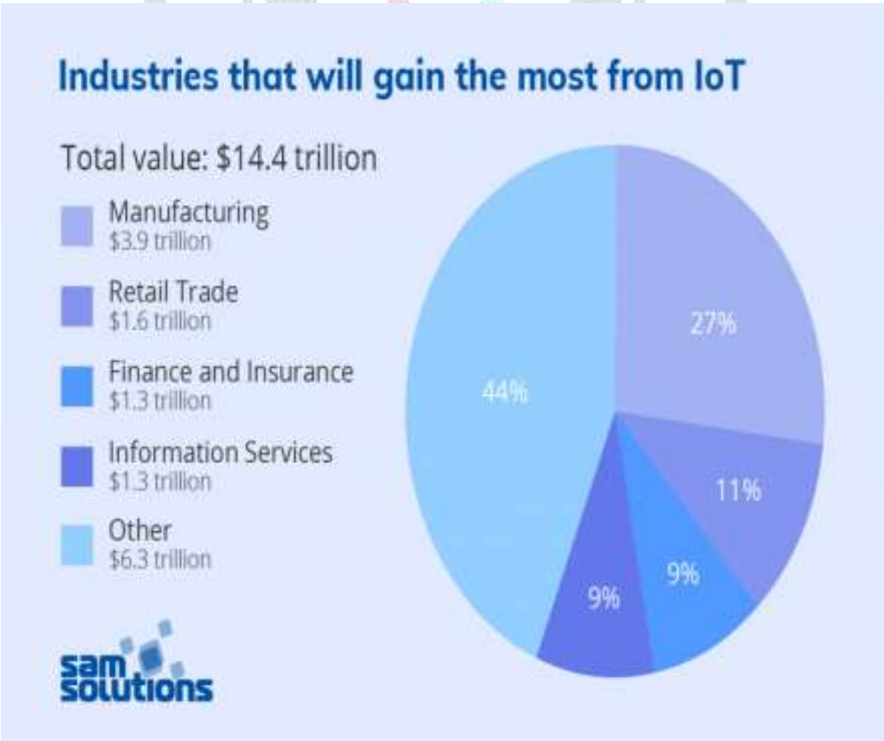

Fig 7: Industries which will gain the most from IoT

A survey conducted in Germany by PwC reveals the following findings:

- 91% of enterprises are investing in IoT and smart manufacturing
- 6% consider their factories to be fully digitized
- 75% invested in digital factories in order to better meet customer preferences
- 50% of respondents expect ROI from digitization in five years
- Companies expect a total of 12% efficiency gains over five years

The German industrial IoT market will see rapid growth by 2025 in terms of three components: solution, service and platform.

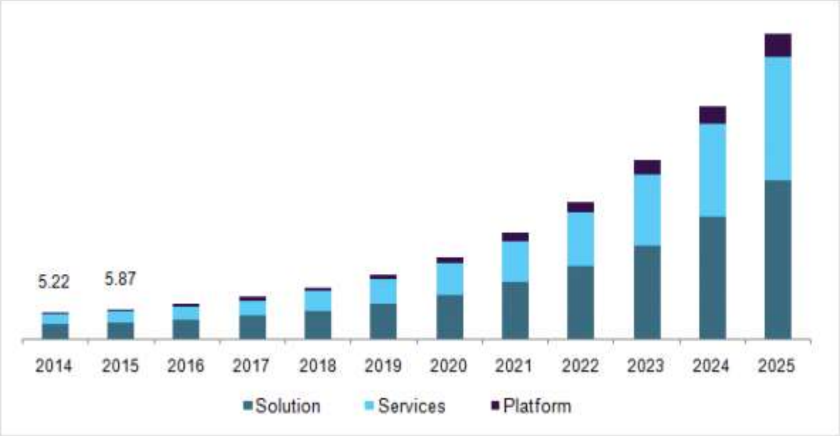

Fig 9: The German industrial IoT market - Growth

The implementation of advanced IoT systems will have one most important consequence — it will enable the entire supply chain transformation and its efficient management. Infinite data gathered by sensors and connected devices will open endless commercial opportunities for the manufacturing industry in the near future.

Table 1: Future of Manufacturing with IoT

Industry	**Key Change**	**Potential Benefits**
Healthcare	➢ Remote monitoring of staff and patients ➢ Ability to locate and identify status of equipment	➢ Improved employee productivity ➢ Efficient resource usage resulting in effective gains and cost savings
Transportation and Automotive	➢ Real-time driving behavior Traffic and vehicle diagnostics	➢ Improved customer experience ➢ Reduced pollution ➢ Increased safety and added revenue streams.
Retail	➢ Prevention of out-of-stock situations through connected and intelligent supply chains	➢ Ability to predict consumer behavior and trends using data from video surveillance cameras, social media, Internet and mobile device usage
Infrastructure	➢ Smart lighting, fire, water, power, cooling, alarms and structural health systems	➢ Better utilization of resources & significant cost savings ➢ Preventive maintenance of critical systems
Supply Chain	➢ Real-time tracking of parts and raw materials ➢ Pre-empt problems ➢ Address demand fluctuations ➢ Efficient management of all stages of manufacturing	➢ Reduced working capital requirements ➢ Improved efficiency ➢ Avoids disruptions in manufacturing
Oil and Gas	Smart components	➢ Reduced operating costs and fuel

		consumption
Utilities	Smart grids and meters	➢ More responsive and reliable services; significant cost savings for both utilities and consumers resulting from demand-based and dynamic pricing features.
Insurance	➢ Innovative services such as pay-as-you-go insurance.	➢ Significant cost savings for both insurers and consumers.

V. CHALLENGES

Transformation of large, mature systems always requires a lot of effort and energy, no matter the industry. The adoption of the Internet of Things and smart manufacturing development may face some significant challenges.

5.1 Security - Security remains the greatest concern of all connected devices. Today, manufacturing has become the primary victim of hacking attacks. When traditional factories transform into digital ones, they turn into IP-based systems where each connected item is vulnerable to cybercrimes. Manufacturers must adapt to sophisticated hacking technologies in order to avoid data loss, theft of intellectual property or other interventions. Legacy equipment that incorporates IoT technology should be equipped with defensive tools. If a new connected environment is created, the security strategy should be considered from the very beginning.

5.2 Skills gap - With the increasing number of smart factories, the skills gap among employees expands. Modern technologies implemented in production require qualified specialists and data scientists who understand new processes and can manage them. It can be also difficult for industry executives to make decisions due to lack of knowledge and IoT competencies. As a result, over the next decade, 2 million manufacturing jobs may be vacant due to the skills gap. To address this problem, educational training on the Internet of Things and other technologies should be implemented as soon as possible.

5.3 Seamless integration - One more challenge is how to seamlessly incorporate all devices into a huge manufacturing infrastructure. In this case, other intelligent solutions such as artificial intelligence, machine learning or augmented reality should be used to simplify the process.

VI. CONCLUSION

The intend of Industry 4.0 signifies the promise of a new Industrial Revolution—one that marries advanced production and operations techniques with smart digital technologies to create a digital enterprise that would not only be interconnected and autonomous but could communicate, analyze, and use data to drive further intelligent action back in the physical world. It represents the ways in which smart, connected technology would become embedded within organizations, people, and assets, and is marked by the emergence of capabilities such as robotics, analytics, artificial intelligence and cognitive technologies, nanotechnology, quantum computing, wearable, the Internet of Things, additive manufacturing, and advanced materials. While its roots are in manufacturing, Industry 4.0 is about more than simply production. Smart, connected technologies can transform how parts and products are designed, made, used, and maintained. They can *also* transform organizations themselves: how they make sense of information and act upon it to achieve operational excellence and continually improve the consumer/partner experience. In short,Industry 4.0 is ushering in a digital reality that may alter the rules of production, operations, workforce—even society.

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