A Seminar Report on

Industrial Internet of Things (IIoT) In Smart Manufacturing

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INDEX

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Kedar Sameer Wadhavkar

ABSTRACT

Full automatization with least human intervention is what the ultimate goal of any industry is. It is nothing but a developed industry 4.0, looking after consumers need independently with the best feasible output.

Industrial Internet also called as Industrial Internet of Things (IIoT) is the base of this colossal development upon which the industries would cultivate on to become a smarter one. IIoT is nothing but the interconnection of various things facilitating interaction between them. This connectivity allows for data collection, exchange, and analysis, potentially facilitating improvements in productivity as well as efficiency.

Also, emphasis is given on why a manufacturing technique to be smart is important in coming period of time. A case study on one of the manufacturing techniques is also stated to help clear the idea of smart manufacturing making use of the Big data, the Internet and other relative concepts.

The following brief research throws light on all these points and are explained in detail along with them proving to be a boon in upcoming years to the mankind.

CONTENTS

LIST OF FIGURES

1. INTRODUCTION

The term Internet of Things (IoT) is estimated to have born in the years 2008-2009. IoT can typically be defined as, a global network of "things" i.e. physical and virtual devices having separate identity to each of them, which can be connected via a vast network to share data and process it into meaningful information. It is nothing but a concept of a thing or an object being connected with the internet, or a couples of things interconnected via the internet to extract a meaningful result. IoT enabled the humans to interact with the things in a smarter way to fulfil a certain objective.

The data from large number of devices are collectively merged together to process a specific information with the help of IoT infrastructure. All those devices that make use of internet or are able to access the internet are termed as smart devices. These devices referred as "things" use various protocols like TCP, UDP, IPv4, HTTP, etc. and lot more in different layers to communicate between each other. Following these protocols enables users to interact ethically and efficiently with the devices.

IoT is aiding many sectors especially the industrial ones, to automate the day to day work vey fluently. Some of the emerging trends in development and deployment of IoT based applications are shown in the figure given below.

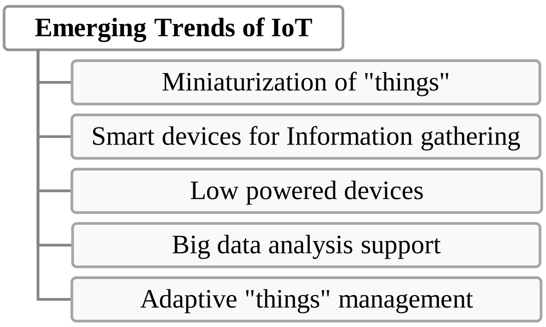

Fig. 1.1: Emerging Trends of IoT

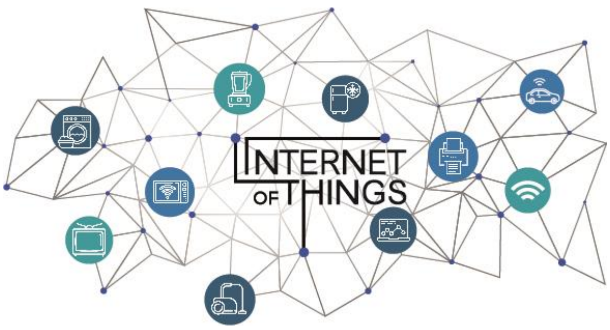

Fig. 1.2: Depiction of IoT

- **Miniaturization of "things"**: Due to advancements in the microelectronics as a virtue of IoT, it is easier to create smaller and smaller things. E.g. mobiles.
- **Smart devices for information gathering**: Smart devices like mobiles, tabs having technologies like camera, Bluetooth, WiFi, etc. enables the devices to sense, read data sensed by things in IoT applications. E.g. Barcodes can be read using camera.
- **Low powered devices**: IoT applications make use of things which are low powered devices so energy consumption is one of the main focus while using such devices.
- **Big Data analysis support**: Availability of cloud and its fluent communication with IoT "things" provides support for big data. E.g. Google cloud.
- **Adaptive "things" management**: Due to increasing demands day by day, for adding new devices and updating previous ones, self-monitoring and self-configurable things are required. E.g. laptops.

2. LITERATURE SURVEY

Various papers, blogs, seminar, forums, websites were studied based on the topic during the course time of the brief research. The main concepts encountered in the research are briefly discussed ahead.

Fig. 2.1: Main Concepts of the Research

2.1. Industrial Internet of Things (IIoT)

The Industrial Internet of Things (IIoT), also known as the Industrial Internet, is one of the most talked about industrial business concepts in recent years. It refers to the interconnection of sensors, instruments, machinery, and other devices networked together with computers, industrial applications, including manufacturing via the internet.

The Industrial Internet provides a way to get better visibility and insight into the company's operations and assets through integration of machine sensors, middleware, software, and backend cloud compute and storage systems. The IIoT envisions machines that tell operators how to optimize productivity or detect a failure before it occurs, potentially saving companies billions of dollars a year.

2.2. Smart Manufacturing

Smart manufacturing is a broad category of manufacturing that employs computer integrated manufacturing, high levels of adaptability and rapid design changes, digital information technology, and more flexible technical workforce training. It aims to merge the digital and analog worlds by building connectivity and orchestration to provide an enhanced processes that delivers goods smoothly and consistently.

Some of the key technologies involved in Smart Manufacturing include big data processing capabilities, industrial connectivity devices and services, and advanced robotics.

2.3. Industry 4.0

The term Industry 4.0 stands for the fourth industrial revolution. Best understood as a new level of organization and control over the entire value chain of the lifecycle of products, it is geared towards increasingly individualized consumer requirements. IIoT is making wonders in industries starting from the planning phase till the complete supply chains management. Inventory management, goods authentication, RFID used for monitoring products, using location based services to track packages for delivery, real time stock monitoring, etc. are being done in the industries.

Industry 4.0 deploys the tools provided by the advancements in operational, communication, and information technology to increase the levels of automation and digitization of production, in manufacturing and industrial processes. By combining machine-to-machine communication with industrial big data analytics, IIoT is driving unprecedented levels of efficiency, productivity, and performance. And as a result, industrial companies in original equipment manufacturing, chemicals, food and beverage, automotive, steel, and many other industries are experiencing transformative operational and financial benefits.

2.4. Summary of the Literature Survey

The IoT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and supply chain networks, by networking machinery, sensors and control systems together. Hence, it can be concluded that IIoT is a subset of Smart manufacturing. That is, manufacturing makes use of Industrial internet to improve the productivity. While, Smart manufacturing is just a subset of the colossal industry 4.0 concept that involves all the sectors right from demand of consumer to the end of the supply chain. The following figure integrates the above statement.

Fig. 2.4: Subset integration of each other

3. IOT TECHNOLOGIES USED IN SMART MANUFACTURING

There are nine identified technologies that are said to be primarily instrumental in shaping industrial production. The following sections discuss each of them.

Big Data and Analytics

These days, the manufacturing sector is getting inundated with an increasing amount of data from various sources, and there is a need to gather all that data, segregate and organize it in a coherent manner, and use the analytics provided by the data sets to support management's decision-making. Business cannot afford to ignore the data coming in, as they might prove to be very useful when it comes to optimization of production quality and service, reduce energy consumption, and improve efficiencies in the production process.

Big data analytics provide efficient and effective methods and tools to handle large-scale IoT data for information processing and manufacturing process control.

Fig. 3.1: Big Data Analytics

The Industrial Internet of Things (IIoT)

Embedded computing and networking will connect transducers and devices and these are an essential part of Industry 4.0. The Industrial Internet will make this possible, since transducers and field devices designed for the IoT, enable them to interact and communicate with each other; while also becoming connected with a gateway to a control and management layer, will become ubiquitous throughout the Smart Factory and supply chain.

Digital control systems to automate process controls, operator tools and service information systems to optimize plant safety and security are within the purview of the IIoT.

Fig. 3.2: Industrial Internet

Cloud Computing

The large datasets involved in Industry 4.0 means data sharing will be not only desirable but imperative to leverage the full possibilities within the value chain. However, few manufacturing plants will have the storage capacity to store and analyse the vast amounts of data collected. Cloud computing provides internet based computing services, including data storage, data management, KPI computation, data visualization and data analytics amongst others.

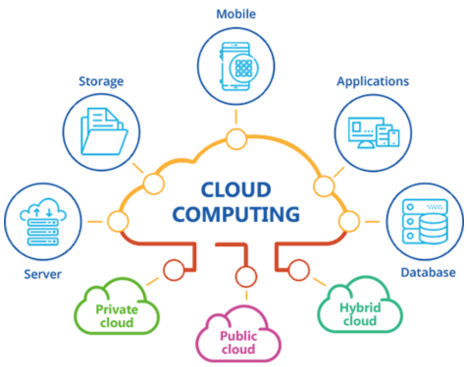

Fig. 3.3: Cloud Computing

Autonomous Robots

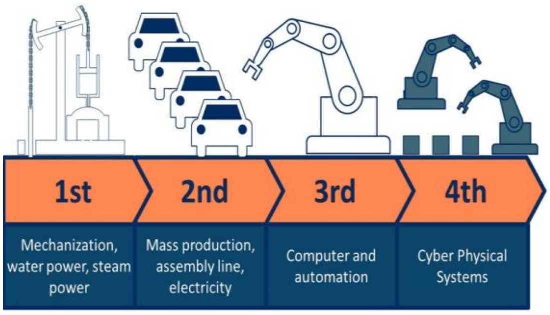

Fig. 3.4: Autonomous Robots

The use of robots in the manufacturing process is no longer new; however, robots are also subject to improvements, upgradation and evolution. Creators of these robots are designing them to be self-sufficient, autonomous, and interactive, so that they are no longer simply tools used by humans, but they are already integral work units that function alongside humans.

Simulations

Previously, if manufacturers wanted to test if a process was working efficiently and effectively, trial and error was required. Now making use of IoT, digital twins are virtually created that are used for simulation, modelling and testing and they will play more major roles in the optimization of production, as well as product quality.

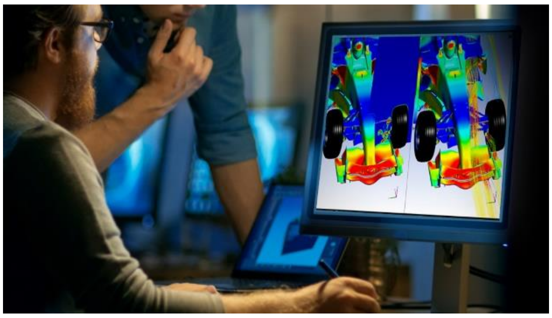

Fig. 3.5: Simulations

Augmented & Virtual Reality

Businesses are increasingly looking to reduce the maintenance and training overheads associated with production, marketing, and after-sales support. Manufacturers are turning to augmented-reality-based systems to enhance their maintenance procedures while lowering the costs of having experts onsite.

Fig. 3.6: Virtual Reality and Augmented Reality

The integration of Virtual Reality (VR) and Augmented Reality (AR) with IoT systems is conducive to asset utilization, labour training, root cause diagnosis, and maintenance, among others. VR enables a person’s physical presence in the virtual environment and simulates human interactions with virtual objects.

Advanced Manufacturing

Additive Manufacturing which has advanced in the recent years, refers to a process by which digital 3D design data is used to build up a component in layers by depositing material. Additive manufacturing such as 3D printing enables manufacturers to come up with prototypes and proof of concept designs, which greatly reduces design time and effort. It also enables production of small batches of customized products that offer more value to customers or end users, while reducing cost and time inefficiencies for the manufacturer.

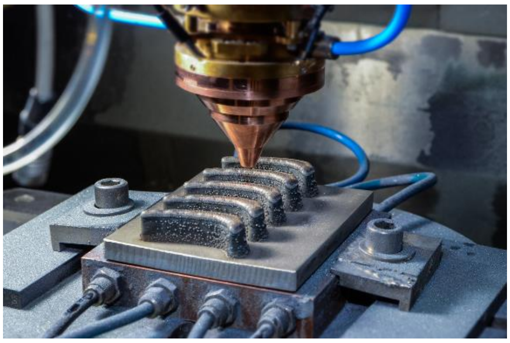

Fig. 3.7: Additive Manufacturing

Horizontal and Vertical System Integration

Horizontal integration has come to refer to well-integrated processes at the production-floor level as well, while vertical integration means that the production floor is tightly coordinated with higher-level business processes such as procurement and quality control.

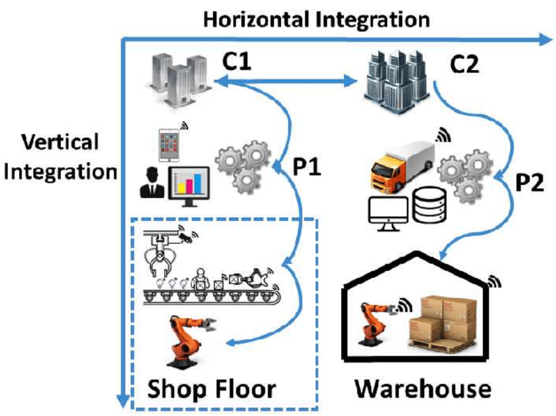

Fig. 3.8: Horizontal and Vertical System Integration

Having fully integrated OT and IT systems is something that Industry 4.0 aims for. The goal is to create a scenario where engineering, production, marketing, and after-sales are closely linked. Similarly, companies in the supply chain will also be more integrated, giving rise to data integration networks, collaboration at automation levels, and value chains that are fully automated.

Cyber-Security

Industrial systems are becoming increasingly vulnerable to threats, as can be seen by recent attacks on industrial targets. To address this, cyber security measures have to be put in place that recognize the new vulnerabilities and challenges that integrating industrial control processes and systems with the Internet producers.

Fig. 3.9: Cyber Security

4. CASE STUDY (ADVANCED ADDITIVE MANUFACTURING)

Production of complicated shapes at high volume and speed, with lower cost is a dream of every industrial unit. One such industrial unit which has this scope is the unit of Advanced Additive Manufacturing.

4.1. What is Additive manufacturing (AM)?

Additive Manufacturing (AM) is more commonly known as 3D printing. It is the selective addition of material to build up shapes and features of components. Components are fabricated by adding small discreet volumes of material in a sequential manner, typically done in layers. The most common approach is called Fused Disposition Modelling (FDM).

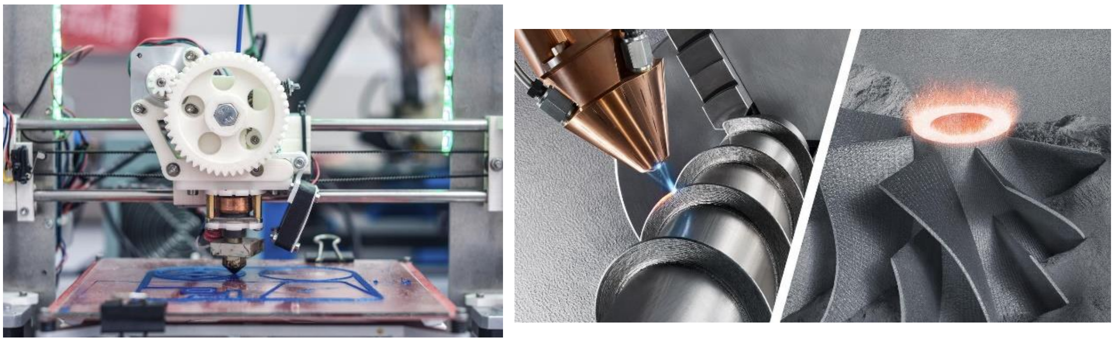

Fig. 4.1.1: Additive Manufacturing and its Product

The material that 3D printers use to make objects are made from a thin thread and the thread is carefully laid upon each other to create the final shape of the product. The thread is heated and fuses with each other as the material is being created.

4.2. How does Additive Manufacturing (AM) Work?

Additive manufacturing uses data from Computer-Aided-Design (CAD) software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes. Objects are digitally defined first in computer-aided-design (CAD) software and then is used to create ".stl" files that essentially "slice" the object into ultra-thin layers. This information guides the path of a nozzle or print head as it precisely deposits material upon the preceding layer. Or, a laser or electron beam selectively melts or partially melts in a bed of powdered material. As materials cool or are cured, they fuse together to form a three-dimensional object. The journey from .stl file to 3D object is the most revolutionized one which has numerous technical advancements.

4.3. Smart or Advanced Additive Manufacturing (AAM)

Since AM machines are Computer-Numerical-Controlled (CNC), they provide significant features to integrate the machines via computers and transfer data (of the object to be manufactured) between the processing units. The benefit of this integration is that the processes can be controlled online, and the products can be highly customized. In addition to that, digitization helps in continuous monitoring of feedstock monitoring, supply evaluation, and availability of machines for a fabrication process.

Industrial companies which fabricate mechanical objects via AM processes are constantly working to digitize their production processes by looking into different aspects of part design, tooling considerations, supply chains, and quality tests on the fabricated specimen throughout the life cycle of the parts they produce. The data generated in the whole stages of idea generation for a new product to waste management or reuse of the products can be digitally sorted and investigated to further optimize the parameters that are involved through the fabrication process. These data management and evaluation processes are known as a digital threads (DT). Considering the volume of fabricated parts via AM processes all over the world on different materials with different process parameters, a valuable source of data can be integrated to optimize the AM processes in use and take further advantage of them.

4.4. Cloud Manufacturing

The other ability of AM processes is known to be Cloud Manufacturing or Cloud Computing Manufacturing including the internet of things, the utilization of cloud computing, virtualization, and advanced service-oriented manufacturing processes, for developing the most efficient models of manufacturing regarding material and equipment usage.

Fig. 4.4.1: Cloud computing Manufacturing

To make the personalization of the products easy, smart product manufacturing and its service features are conceptualized to form a Smart Service Product (SSP) which attributes to the change in consumer attitudes and the development of advanced information communication technology (ICT). This concept can be utilized in managing and understanding the personalized demands of the market and the customers. The implication of SSP results in easy demonstration of customizable smart product design. Since the digitization of the manufacturing processes is closely related to the implication of computer-controlled machines, AM processes are the best targets of cloud manufacturing.

Data-related manufacturing processes, and especially AM processes, are based on automated machines which are precisely controlled by computers and as a result, there is always the flexibility of controlling and customizing processes based on customer needs and supply availability. In this case, product optimization can be conducted more efficiently, and the processes and software used for them are more user-friendly.

4.5. Advanced Additive Manufacturing as Industry 4.0

Researches showed that the AM processes can be investigated on process deployment, resource management, material flow, and task management in industry 4.0 which are not easily accessible in other manufacturing processes. This shows the potential of AM processes as the future tools for making customer-specific products with the lowest price.

Fig. 4.5.1: Advanced AM as Industry 4.0

Computer vision algorithms can be used to apply production planning in AM processes. In this process, the tasks are first segregated based on their priorities, the difficulty of fabrication, geometry of the product, etc., and the sorted tasks go through levels of fabrication and the computerized control over the process continues to the point that the product is finalized.

Another framework that benefits various businesses and technologies is big data and it is forming an interdependent relationship with AM. The use of big data-based analytics in the context of industry 4.0 helps to improve the process performance and energy efficiency and increases the quality of manufactured products. AM's reliance on big data grows with increasing AM applications in the industry since by its growth it needs more data to perform its capabilities. Big data plays a role in CAD and quality control aspects of AM processes. In the case of the complex AM parts and structures, an alignment error or a fraction of a millimetre geometrical inaccuracy can be dangerous depending on the part application. This is where big data can analyse each AM process and inspect every element to find when these imperfections occur.

4.6. Conclusion of the Case Study

As seen in case study, how a normal AM can be upgraded to an advanced one, many other manufacturing processes can as well be upgraded using the IIoT. The productivity eventually increases with this upgrade and apparently improve the economy of the unit. Thus, similarly traditional manufacturing processes can be made smart and can lead to a successful concept of Industry 4.0.

5. WHY IS SMART MANUFACTURING IMPORTANT?

Smart Manufacturing spread can enable the realization of the objectives of effectiveness and efficiency, in terms of increased revenue and reduced costs, thus enabling an improvement in competitiveness that will enable industrial enterprises to expand their business volume and consequently have positive effects on employment.

Smart Manufacturing can also facilitate and simplify the introduction of new products and processes. Video communication and collaborative technologies generally contribute to a more rapid and effective design of new products. The availability of analytical data allows you to minimize the risk of re-working compared to a finished product that, for whatever reason, does not comply with the desired specifications and design. The definition of a well-established and tested technology practice helps to speed up the start-up phase of new production facilities.

6. ADVANTAGES OF SMART MANUFACTURING

- **Improved Productivity**

Smart manufacturing processes provide greater access to data across an entire supply chain network. Real-time data outlines what the manufacturer needs and when, which makes things more efficient for suppliers that can easily make adjustments to orders. They supply what’s needed, not more or less, reducing waste and any downtime associated with missing parts.

- **Innovation and Higher Quality Products**

When productivity is improved, it saves money, which can then be invested in product development. Once analyzed, smart manufacturing data shows where customer needs are and managers can find opportunities for new products or re-imagined products of a higher quality.

- **More Manufacturing Jobs**

Adopting smart manufacturing is a way to attract the younger, tech-savvy workforce since more technology-based manufacturing jobs will become available. Utilizing smart manufacturing data and apps, employees can recognize new opportunities and increase productivity. Smarter factories offer the opportunity to boost employment lot many times over the current manufacturing workforce.

- **Energy Efficiency**

All manufacturers can reduce their carbon footprint by reducing waste, but energy intensive industries have the most to gain in terms of energy savings that will not only reduce energy waste but also make products more affordable because of it.

7. FUTURE SCOPE

Based on such a highly integrated smart cyber-physical space, it opens the door to create whole new business and market opportunities for manufacturing. Cyber-physical systems (CPS) is the core technology of industrial big data and it will be an interface between human and the cyber world. Industrial big data analytics will play a vital role in manufacturing asset predictive maintenance, although that is not the only capability of industrial big data.

Industrial IoT (IIoT) in manufacturing could generate such a business value that it will eventually lead to the Fourth Industrial Revolution (Industry 4.0) overall in the world. The potential for growth from implementing IIoT may generate $12 trillion of global GDP by 2030.

This will significantly improve user experience and operator safety and ultimately save on costs.

According to the statistics, in the upcoming years, benefits to the global economy through IIoT will be:

- 46% of global economy that can benefit from the Industrial Internet
- 100% Industrial Internet potential impact on energy production
- 44% Industrial Internet potential impact on global energy consumption

As more and more data is being generated from increasingly connected machines, systems, and devices, the volume of critical and valuable insights to be realized and acted upon is limitless and ever-increasing.

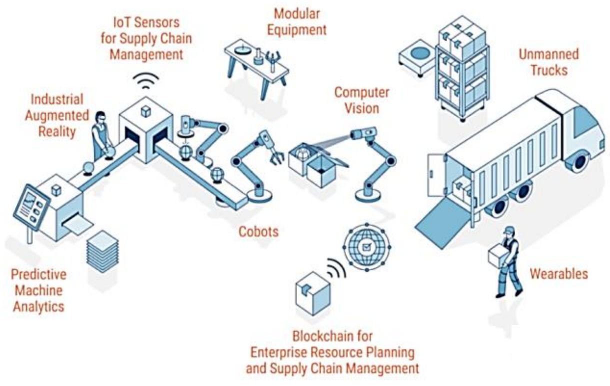

Fig. 7.1: Futuristic Industry 4.0

8. CHALLENGES FACED IN IMPLEMNTING IIOT

As every coin has 2 sides, similarly IIoT too has some shortcomings. Implementation of IIoT in smart manufacturing has quite a few challenges, due to which it is not possible for everyone to establish it. Some of them are listed below.

Connectivity Outage Challenge

There is a constant need for uninterrupted connectivity if an enterprise is planning to go IIoT. Even while using Internet connectivity, its availability of 100% is nearly impossible. Either for maintenance or for some other reason, at one point of time, the connection is lost. If an enterprise is planning to implement IIoT technology in their system, the critical need is to be present with an unremitted connection. It would be best to make sure to use the proper cables and set a system that guarantees zero data loss—even in case of connectivity Issues.

Fig. 8.1: Connectivity Outage Challenge

Incompatibility of Machines

With numerous vendors, OEMs, and service providers, it becomes really difficult to maintain interoperability between different IoT systems. Sensors and Networking are the integral components of IoT. But not every machine is equipped with advanced sensors and networking capabilities to effectively communicate and share data. Besides, sensors of different power consumption capabilities and security standards inbuilt in legacy machines may not be capable to provide the same results.

Fig. 8.2: Incompatibility of machines

Delivering Value to Consumer

The plan to implement IIoT solutions can severely impact the efficiency, customer satisfaction, and productivity in the long run. Having IIoT is a big deal and the entire cycle needs great understanding as any business usually plans for new technology to fill the gap of understanding the customer problem statement.

Fig. 8.3: Delivering Value to consumer

Hence, it becomes extremely crucial for IoT consultants to figure out the key performance indicators to measure and improve through an IoT solution.

Data Storage

One of the major challenges for enterprises is Data storage. Today all forecasted activities heavily rely on the stored data from the past. No enterprise lives with an old traditional method to tackle data which usually would be analysing high-frequency data, analyse it, and promptly throw it away. Industrial Internet of Things supports to collect thousands of data points that have critical relevance to future aspects of the business outside of the OT network. And hence it becomes a necessity for any enterprise to plan for a secure storage of data before going full IIoT in long run.

Fig. 8.5: Data Storage Challenge

Security

There had been numerous cases of cyber-attacks in the past. It's much important to save critical data from cyber-attacks than maintaining typical IT networks. This had been the biggest IIoT challenge for the operation and technology teams since a regular threat can ruin the enterprise. Even if a company plans to overcome such issues with IIoT, this would mean introducing new security tools to the network which means increased cost and heavy maintenance. Thus, businesses are usually resisting the idea of IIoT until they are equipped with a solid security plan in place.

Fig. 8.5: Cyber security Challenge

Analytics Challenge

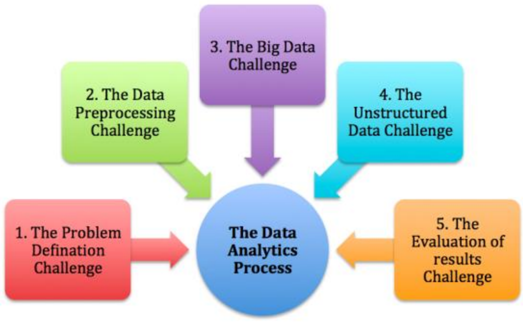

Fig. 8.6: Data Analytics Challenge

Even if IoT solution is implemented in the enterprise, its actual ROI value is realized through actionable insights derived from the collected IoT data. This could only be possible with the help of a high-performance analytics platform that can handle the gigantic amount of data added to the solution.

While implementing IoT architecture, it's important for Data Analytics partners to involve data processing, cleansing, and representation too. This ensures leaving enough space for extensibility factor to add real-time or predictive analytics to an IoT solution.

9. CONCLUSION

To sum up the brief research, it can be said that overcoming the challenges, slowly trying to make maximum use of internet, will gradually help raise the standard in terms of productivity. Also the big data available of all the previous tenders, contracts can be analyzed to extract better quality of production. It can not only improve the supplies but also increase quality demands. Smart manufacturing also limits human efforts as the machines can be self-controllable.

Investing a certain capital initially for the setup, can extract large profits later in the following years. A large investment is also required as this fields also require skilled employees viz. data analysts, robotics specialists, etc.

Upgrading the existing machinery for enabling them to connect to the internet, clouds is a bit difficult. But, in the following years if this challenge is overcome, then there is a great opportunity for everyone to upgrade to the industry 4.0. The tremendously increasing demand of the ever increasing population can also be satisfied if the traditional industries are transformed into 4.0.

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