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Industrial IoT in Manufacturing and Supply chain Management

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Abstract: With the rise of data singularity and interoperability, most manufacturing firms have transformed into smart factories enabling digital technologies such as Industrial IoT and cloud-based services. With the increase product demand, the production becomes more advanced which results in complex and composite supply chains. Every stage of the product development is generally carried out using different suppliers and in various locations across the globe. There is huge exchange of data between every stage, leading to multiple data sharing and collection arrangements. This challenges the efficiency of both, the manufacturing firms and the supply chains. The application of IoT here is to not only provide a link between databases and servers, but also to maintain a constant connection between OEMs, partners, manufacturers and the consumers. This paper reviews over the significance of IoT in manufacturing operations and supply chain management, providing insights into the benefits and the challenges faced.

Keywords: Manufacturing, Industrial IoT, Supply Chain Management

Introduction to IIoT

In the past years, the 4th Industrial revolution has taken over the manufacturing sector and impacted it on a great level. The introduction of cyber-physical systems, Industrial IoT, Cloud based design and the computerization of manufacturing has changed one's perspective towards engineering and production technology. Earlier, enterprises focussed on developing an assembly technology which assured product development, despite being labour-intensive and time-consuming. Currently, modern manufacturers use the power of cognitive technology and cloud computing to reduce downtime, service costs and failures. [1]

Networking and resource sharing was not considered to be a part of the supply chain

before but now, the entire manufacturing process and the product life cycle depends on it. Every stage starting from the OEM (Original equipment manufacturer) to the various tiers of the supply chain and also, the consumer are involved in an industrial network using the Internet of Things. Often called as the Industrial Internet of Things. The Industrial IoT is an interlinked and meshed network of various encoders, sensors, machinery, individuals and the internet. IIoT collects data from machines and sensors, and delivers this information as valuable intuitions using the cloud to the concerned personnel. This data usually comprises of efficiency parameters, quality assurance, time constraints and fuel & power usage. [2][3]

In Digital Manufacturing, several supply chains fuse together and often result in complex timelines and schedules. Managing the logistics, schedules and interoperability in factories generate huge amounts of data, which requires the Internet of Things to perform analysis and real-time surveying. This framework allows enterprises to link the Business IT to the manufacturing IT, optimising B2B, B2C and even B2G relations.

The first 3 industrial revolutions are meant to be driven by mechanical techniques using water, steam power, extensive labour and the usage of electronic and automated assemblies. Industry 4.0 aims to comprehensively use autonomous systems using the cloud, cognitive computing and of course, the Internet of Things. Hence, it is technology-driven or perhaps, data-driven. [4] Industry 4.0 aims to increase the overall equipment efficiency, quality of products and the productivity rate of SMEs. This paper aims to elucidate the adoption of Industrial IoT in manufacturing and supply chain blocks, the benefits acquired and the challenges faced.

IIoT in Manufacturing

After the outburst of Industry 4.0, Manufacturing is not a purely mechanical-driven approach any longer. ‘Smart’ manufacturing has become a mechanical and technology-driven force which has proved to be far more efficient and robust in its applications. Smart Manufacturing in itself is an application of Industrial IoT which comprises of exchange of huge amounts of data between machines, factories, people and also companies.

IIoT-infused manufacturing aims to increase the global productivity rate by 25% by 2025. It forms a ripple of products, processes and engineers. It has proven to optimize manufacturing operations and also, the logistics involved in carrying out production processes. It connects the physical world of manufacturing to the digital world of analysis, tracking and management [5].

Most companies do not eye the benefits of IIoT and cloud-based manufacturing, at first. They get intrigued by the ease it can provide to complex interoperability functions and the virtualisation of expensive and extensive manufacturing processes. IoT is mostly a service provided to enterprises which can conveniently and efficiently be integrated to the pre-existing IT infrastructure. It allows re-designing, re-processing and re-manufacturing of products on a much lower cost and in much lesser time.

Most manufacturing giants including Volkswagen Group, Toyota and Apple Inc have converted large sections of their factories into ‘smart’ factories. All processes, data and information get stored to a centralised server which works as a common cyber infrastructure facility for data collection, storage and sharing. This cyber infrastructure allows integration of hardware such as tools, sensors, machines, autonomous robots and software components such as virtual databases, user interfaces and industrial networks in the supply chain. This has aided manufacturing enterprises to manage Intellectual property (IP), schedule workflows, inspection calls and most importantly, interoperability of machines and servers.

According to a study by IDC and SAP in 2017, 60% of global manufactures used IoT to access data transmitted from various devices and machines. Business Insider also forecasted that by 2020, 75% of new cars will be IoT-enabled, which has proven to be true. IoT is being used in ever process, product and service which even requires minimal exchange of data and

information. Manufacturing being a powerhouse of processes and products, it almost depends on the unprecedented access to the cloud and cognitive abilities.

Benefits of IoT in Manufacturing

In digital manufacturing, multiple data stream need analysis, often simultaneously. In order to undertake this measure, computational platforms are need to link the hardware to the software, and that's where IoT helps in handling the big data with the ongoing predictive maintenance. As we have established that manufacturing processes and IoT go hand in hand, there are number of significant impacts on the industry which has not only benefitted on a financial level but also on a networking level.

Interlinked factories: Using IoT-enabled machines, manufacturers have the ability to share and exchange data from different machines inside the factory and also from different factories on various tiers of the supply chain. Operation managers have access to every aspect of the supply chain remotely, allowing them to make changes and schedules in real-time.

Operations: IoT allows manufacturers to streamline production lines in accordance with the current conditions. Some processes depend on factors such as temperature, vibration, availability of lubricant, electricity and raw material. These conditions are checked by constant monitoring of data received from assorted machines and equipment in the factory. By ensuring these cognitive operations before starting production, it reduces cost, downtime and accidents.

Predictive maintenance: Adding sensors in factories which help in monitoring production flow generates huge amounts of data, often called as Big Data. This data is studied, analysed and refined using the cloud, which in turn allows us to create predictive models. Due to prognostics such as power failures, weather conditions and shortage in inventory, manufacturers make adjustments to manage and reduce operational costs.

Customisation and Quality: By means of IoT, consumer experiences can be studied and products can be iterated accordingly. This allows product customisation at a minimum cost and speeds up its way to the market. This production demand planning allows manufacturers to provide what the consumers actually desire.
Besides customisation, quality control using IoT has enabled enterprises to sell products after checking on factors such as composition of raw material, heating impact, generation of waste, machining processes and even packaging.

Safety: Factory men nowadays are equipped with sensor-enabled helmets and bands which provide alerts and caution in real time when working with dangerous equipment such as hydraulic forging presses, furnaces and metal fabrication.

Besides these benefits, IoT has proven to be the driving force of almost all manufacturing and logistics processes enabling resource sharing, automation and design thinking. It offers perceptions to designers, manufacturers and even consumers to re-engineers products for better performance and utilisation.

Challenges faced:

IoT connects every product, machine, worker, tiers in the supply chain all together, causing a huge exchange of data. Such combination of interlinking physical and digital components, comes at its own price. There are several threats and security concerns while using the cloud and other cognitive solutions provided by the Internet of things.

Privacy: When a large number of people are involved in the supply chain, privacy concerns often rises. It has become easy to leak IP addresses which can be used to track shipments and other product information. Nowadays, VPNs (Virtual Private Networks) are used along with IoT solutions so as to encrypt all data in your system. Only authorised personnel are given access to specific information blocks from the database.

Info-security: Securing manufacturing systems is important when building a high-end cyber infrastructure along with it. Systems can be exploited and responses can be altered when the data is in not secured. This vulnerability causes enterprises to form firewalls and specific domains for data collection, storage and sharing.

Volume: With increasing amounts of data, powerful processors are required to convert the raw data from sensors into useful information. Often entry errors, missing data points and incorrect data paths are detected which cause anomalies in manufacturing processes and the supply chain.

Despite these challenges, IoT has proved to be an efficient bridge for data sharing between machines and technology, tiers of the supply chain, designers and manufacturers and also, consumers. Every threat can be avoided using secured systems, firewalls, data-encryption and access to trusted third-party companies.

Supply Chain Management:

SCM makes manufacturing operations and work processes that deal with the information providers need from customers and the other way around [7]. This can incorporate everything from acquisition, satisfaction, and PO demands, to stock, distribution centre, and delivery/coordination's the board. The general objective of SCM is to decrease inventory piling up without trading off help levels and make manufacturing as lean as could be expected under the circumstances.

The race to move to ERP over Y2K fears has provoked enterprises to increase intensity of information out of even the most moderate operations. There was an overall move to make chains better, data-driven, and more proficient by utilizing the pre-existing data links,

Abruptly, OEMs and brands aren’t simply utilizing their efficient chain to stock their initial pieces. Progressively, they were depending on industrial facilities in the creating scene to manufacture entire gatherings and afterward sorting them out state-side. Supply chain management software in manufacturing is increasingly necessary so that suppliers and designers to develop simultaneously in real-time [8]. For supply chains, the executives in modelling, stacking and assembling, implies that SCM must work intimately with product designers and engineers so that products generate similar data standards and promote data singularity.

As SCM moves to the engineer or the design phase, it'll extract itself slightly from the financial data core of ERP [9]. There will be less functional overlap, and it'll just make sense for SCM to offer a best of breed solution with flexible data pushing/pulling integrations, rather than sitting within the ERP suite.

Typical Supply chain:

A supply chain is a network between an organization and its suppliers to supply and distribute a particular product to the final customer. This network includes different activities, people, entities, info, and resources. The provision chain conjointly represents the steps it takes to induce the merchandise or service from its original state to the client [10]. There are several layers in a supply chain which are in constant with each other providing information, data and instruction along with the exchange of goods and services.

Raw Material:
The supply chain begins with raw material procurement. The process of obtaining products and semi-products necessary for production is called a raw material procurement process. The raw materials are required to manufacture desired parts that sum up for an entire production result. A crude material, otherwise called a feedstock, natural material, or essential item, is a fundamental material that is utilized to create merchandise, completed items, vitality, or transitional materials that are feedstock for future completed items [11].
Logistics Chain:
A tight interlocked and reliable logistics solution is to be established for ruckus free production maintenance and for preventing breakage in the parts flow throughout the chain. There are many factors that affect the reliability of a particular logistics' solution provider.

- Capabilities: An imminent logistics provider must be capable in the particular help zones that address your organization's issues.
- Customer Service: The service provider should be able to keep up with the promised time and should keep up with the industrial demands.
- Safety Record: It's important for a logistics provider to have a strong safety record in order to establish themselves as reliable and efficient.

Parts Suppliers:
Parts suppliers often described as Tier-3 manufacturers produce by-products that are raw or close to raw materials. Tier 3 providers are the establishment of the whole supply chain. They give the necessary materials, for example, metals and plastic, in their crude structure or practically raw state to Tier 2 and Tier 1 organizations. Tier 2 alludes to organizations that produce and flexibly parts from the material acquired through Tier 3 to Tier 1 level. Each separate level concentrating on one part of the item permits them to upgrade the quality and usefulness before its advertising and circulation [12]. Moreover, it empowers the organization to work with the first in class gear and qualified specialists for ideal outcomes by making an exceptional, quality completed item for the end client. All levels are similarly significant for the assembling procedure. In this manner, for the solid activity of the business, all levels should be thorough in their executions [13].

Components Suppliers: Components suppliers, industrially known as Tier 2 refer to organizations that produce parts from the material got by means of Tier 3 to Tier 1 level. Tier 2 firms are comparatively smaller than Tier 1 yet essential for the supply chain [14]. They are a deciding factor in the speed of Manufacturing.

They should hold fast to the security and quality guidelines, so they won't pose any ethical issues to the level 1 consumer. A Tier 2 automotive supplier is, in addition, an SME, is consequently an entity qualified to combine compliance encircling the strict productive and qualitative regulations of the automotive industry with flexibility, speed, and trust. Also, like voice, it is able to start out a contrary proceeding with customers and to directly cooperate with them in order to define the most appropriate, safe, and favourable solutions [15].

Module (or) System Supplier.
A Tier one provider provides the OEM directly. They are followed by Tier 2 and Tier 3 suppliers within the supply chain. Suppliers at rock bottom of the provider hierarchy may also skip levels and provide the OEM — i.e. the manufacturer — directly, for instance.

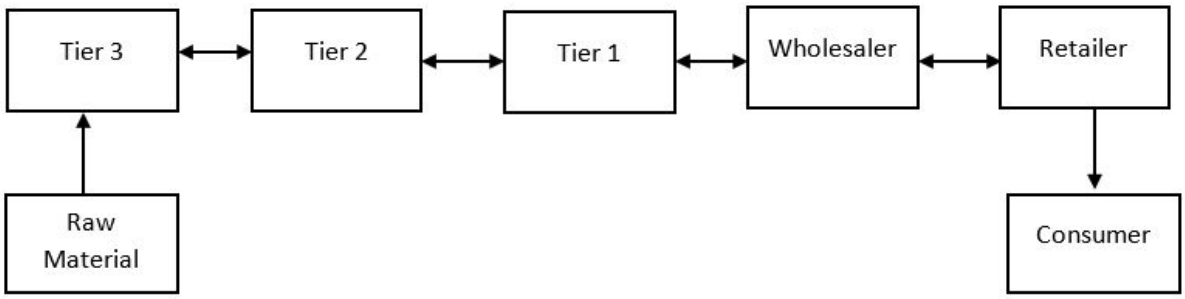

Fig: Supply chain schematic flowchart

Typically, Tier 1 groups offer just superior tactics into the provide chain. This is the last quadrant before the product reaches the OEM whichever may fulfil the production or actually get such equipped for allocation through organizing shipment, marketing the products, and something is wished in conformity with come the manufacture in imitation of the end-user [16].

A Tier 1 corporation eliminates the need of a middleman for the OEM. Such corporations have the strongest credibility with the OEM, as the corporations ought to have validated themselves to be an organization that can generate dependable aspects on time and with strict adherence to safety and standards procedures.

An OEM may additionally have many greater tiers than this, however the relationship between Tier 1 and Tier 2 companies suggests how all of them operate – Tier 2 generates and components, Tier 1 with the merchandise it desires to generate and furnish the OEM with what is wanted for the remaining products. The grant chain is only as strong as its weakest agency link, so having wholesome business practices is essential for every tier to maintain in operation.

IoT in Supply Chain:

The procurement and logistics of material has become model-based with an agile workflow. A typical supply chain extends from the extraction of raw material to the delivery of product to the end user. Hence, IoT infused data networks are used to share information between every tier of the supply chain. In advanced manufacturing environments, sensors are used to collect data systematically. IoT is covered using a range of components such as actuators, sensors such as Lidar, orthographic vision and proximity sensors, embedded systems,

Bluetooth-enabled devices and all machines connected to the internet. Each of these components are connected to each other using the cloud as a platform.

These cloud based services can either be [6]:

SaaS (Software as a service): This server enables the enterprise with access to a supplier's cloud-based software. Instead installing applications, users can rely on the cloud network to store and share data.

PaaS (Platform as a service): Here, enterprises are offered access to a cloud environment for developing and managing their own data. Most factories use PaaS as it simplifies security management, operating systems and server backups.

IaaS (Infrastructure as a service): Different tiers in the supply chain provide access to computing resources such as servers, storage and networking. IaaS saves the enterprise a big amount of money of buying and maintaining their own machines.

As the data is secure in the cloud, enterprises are relieved and even if there is an equipment failure, there is no loss of data. This type of cloud-environments enables information security, easy data recovery and provides rigidity to the cyber infrastructure between various levels of the supply chain. IoT has allowed suppliers and consumers to sustain a constant relationship regarding maintenance, servicing and also, regular updates on software [17]. With the rise in industrialisation, most consumers expect service until dismissal of the product. Even in the Product life cycle, data is generated at each stage, which can be processes and used in the future to detect possible failures.

Benefits of IoT in Supply chain:

All tiers including OEMs, manufacturers, suppliers, logistics and retailers require additional information and instructions along with the physical goods. This data cannot be shared via tangible assets considering data security and duplication. IoT and cloud computing promises data security and easy recovery [18].

1. Industrial Optimisation: IIoT enabled supply chains allow pre-hand processing and simulations which optimise the manufacturing processes. It acts as the communication bridge between different companies, designers and consumers. It reduces wastages and operational time considerably.

2. Safety: It ensures safety of goods during logistics via online tracking and pre-planned paths using different sensors. Most labour-intensive work is being substitutes by autonomous robots which relies on the internet of things for sharing and collecting data. This reduces accidents, fraud, and theft and improves estimate over available data.

3. Interoperability: IoT surely enhances the supply chain as real-time data helps in accurate planning and decisions. It allows individual companies to operate co-dependently in a strong feedback loop which reduces rework and increases efficiency. The increment in reach and participation of enterprises provides promising results in supply chain optimisation. It streamlines process plans, because tiers can use model data for manufacturing and quality assurance instructions.

4. Agile workflow: In different stages of the supply chain, IoT allows developing functionality, integrating designs and testing of prototypes. Instead of designs being changed independently, it can altered and modified in real-time remotely. This access to easy feedback minimises rework and communication gap between different companies.

Despite various benefits, there are a few challenges faced when using the IoT in the supply chains. Many OEMs provide minimal data about the supplied product so that the next tier can revert back for money-making services and extensions. Besides that, maintaining similar data standards is also complicated, as all companies use different variants of software and operating systems. Incompatible data can cause equipment failure and hence reduce increase downtime. Information security & privacy concerns always arise when there is cloud-based exchange of data [19].

Supply chain uses all available business models (B2B, B2C, and B2G) which can sometimes increase complexity and high upfront investment. IoT empowers customers and partners to deploy and demand certain parameters and services. Most manufacturing firms have to undergo multiple government inspections and control measures. The smoke quality and scrap removal have to be carried out in accordance with the norms designed by the government [20]. This can be checked in real-time using sensors and detectors installed onto furnaces and chimneys.

IoT has various political, economic and legal impacts on the supply chain. It acts as the ‘middle man’ between organisations for easy communication allowing convenient data duplications and instruction management. This combined framework of the Internet of Things, Cloud-based services and the supply chain has proven to be one of the most efficient outcomes of Industry 4.0.

The usage of cyber-physical systems, big data analysis, industrial IoT, cloud-based design and manufacturing has permitted effortless processing and maintenance of databases for enterprises.

Conclusion:

This paper analysed the significance of Industrial IoT in production systems and supply chains, the benefits and also the challenges faced. With rising customer demands, manufacturing is advancing which results in complexity in the supply chain. Most companies are not only “Product-based” but also “service-based” now, using IoT maintaining constant contact with partners and customers. It has opened doors to new concepts such as virtual manufacturing, predictive maintenance and digital design technology. It has provided visibility from a supplier and customer perspective, delivery high quality products and providing satisfying customer services.

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