Journal of Advanced Research in Embedded System
Volume 8, Issue 1&2 - 2021, Pg. No. 3-7
Peer Reviewed Journal

Article

Applications of IoT in Manufacturing: Issues and Challenges

Lavanya Madugula

Assistant Professor, Department of Mechanical Engineering, St. Martin's Engineering College, Dhulapally Road, Secunderabad, Telangana State, India.

INFO

E-mail Id:
lavanyam81@gmail.com
Orcid Id:
https://orcid.org/0000-0003-2308-0042

How to cite this article:
Madugula L. Applications of IoT in Manufacturing: Issues and Challenges. *J Adv Res Embed Sys* 2021; 8(1&2): 3-7.

Date of Submission: 2021-05-20
Date of Acceptance: 2021-06-06

ABSTRACT

The Internet of Things (IoT) is the global network of inter-related physical devices such as sensors, objects, computing devices, mechanical instruments, smart applications and human resources that are becoming an essential part of the internet. These devices are the sources of data which provide abundant information in manufacturing processes. In an industrial environment, the Industrial Internet of Things (IIoT) plays a pivotal role in manufacturing. IIoT is the transformation of manufacturing process by making the industries more efficient, productive, and smarter. In order to survive, withstand in the market place and gain competitive advantage, the manufacturers are initiating to leverage IIoT technologies and data analytics. With globalization, global competitive pressures are challenging industries and manufacturing companies to manage the gaps in the workforce skills, drive out inefficiencies from the existing systems and enhance their business opportunities. The world is plunging into an era of data inter-connectivity and companies are able to enhance their production after adapting new technologies. In this context, this paper provides an understanding of the concept of IIoT and smart manufacturing. Further, the paper discusses in detail the issues concerning different applications of IoT in the industrial sector; and presents the challenges encountered in an IoT-based Industrial Data Management System (IDMS), which can manage the huge industrial data, support online monitoring and control smart manufacturing.

Keywords: Industrial Internet of Things (IIoT), Data Inter-connectivity, Smart Manufacturing, Industrial Data Management System (IDMS)

Introduction

New information technologies are offering not only to make the management of manufacturing more effective; but also, the work itself smarter. The Internet of Things (IoT) is a technological revolution that represents the future of computing and communications; and its development depends on dynamic technical innovation in a number of important fields, from wireless sensors to nanotechnology. Technologies based on the Internet of Things (IoT) have the potential to radically improve visibility in manufacturing to the point where each unit of production can be seen at each step in the production process. The "Internet of Things" refers to the coding and networking of everyday objects and things to render them individually machine-readable and traceable on the 'Internet '.

The concept of connecting any device with internet in Industry is called 'Industrial Internet of Things' (IIoT). In an industrial environment, the Industrial Internet of

Things (IIoT) plays a pivotal role in manufacturing. IIoT is the transformation of manufacturing process by making the industries more efficient, productive and smarter. IIoT is a convincing stage by interfacing different sensors around us to the Internet, giving incredible chances for the acknowledgment of brilliant living. It is a fast-growing technology in the present scenario. IIoT has its effect on almost every advanced field in the society. It has impact not only on work, but also on the living style of individual and organization. Due to high availability of internet, the connecting cost is decreasing and more advanced systems have been developed with Wi-Fi capabilities. The applications of Internet of Things (IoT) in different areas such as automotive industries, embedded devices, environment monitoring, agriculture, construction, smart grid, health care, etc. are making human living on earth more comfortable.

The Industrial IoT helps manufacturing enterprises to maximize productivity through maintaining production time, reducing costs and eliminating waste. Leveraging IoT data helps manufacturers in several ways. They get a better understanding of manufacturing and supply chain processes, improve demand forecasting, achieve faster time to market and enhance customer experience. However, considering the scale and the complexity of the Industrial IoT initiatives, successful IIoT adoption requires thoughtful orchestration throughout the IIoT application design and execution segments.

Application of IoT technologies in Industry

IoT technologies are transforming the way production systems are built and run, driving improvements across three main dimensions of the digital transformation, viz., (i) Visibility into shop floor and field operations, (ii) Visibility into the manufacturing supply chain; and (iii) Visibility into remote and outsourced operations.

Dimension 1: Visibility into the shop floor and field operations.

The Industrial IoT offers the revolutionary level of visibility into the shop floor and field operations, as well as the possibility of handy control over enterprise resources. The IIoT technologies help to integrate systems like 'Enterprise Resource Planning' (ERP) and 'Manufacturing Execution Systems' (MES) to increase operational efficiency of the industry. Since the ERP systems contain information regarding inventory and customer demand; and the Manufacturing Execution Systems (MES) control how to build it, the integration of the two could help to enable organizations to become more flexible and more responsive to customized and changing demands. In addition, real-time information exchange between the business layer and the production layer could help to increase the Overall Equipment Efficiency (OEE), reduce cycle times, and provide management with greater visibility for improved decision-making.

By providing manufacturers with second-by-second shop floor data, the IIoT allows businesses to considerably increase manufacturing process productivity. In today's competitive global markets, a sound manufacturing process is more important than ever. Sharing information between the manufacturing floor and business systems can enable manufacturers to achieve new levels of efficiency. With the Industrial Internet of Things (IIoT), they can bring about a great revolution in manufacturing by leveraging intelligent connected devices in factories. In a recent survey by Accenture of more than 1,400 global business leaders, 84% confidently asserted that they could create new income streams from implementing IoT solutions. IBM reports that using IIoT insights for manufacturing process optimization can lead up to 20% higher product count from the same production line.

The IoT applications that allow manufacturers to gain a higher level of vertical visibility fall into two categories, viz., (a) applications supporting manufacturing operations and (b) applications facilitating industrial asset management.

IoT- Driven Manufacturing Operations

According to a research by International Data Corporation, India (IDC-India), by 2025, the improvements in operations driven by IoT applications could be worth more than $ 470 billion per year. IoT applications for manufacturing deal with such operations as monitoring and optimizing equipment performance, production quality control, and human-to-machine interaction.

A research study by Information Technology and Innovation Foundation (ITIF) reports that IoT applications for monitoring machine utilization can increase manufacturing productivity by 10% to 25%; and produce up to $1.8 trillion in global economic value by 2025. The IoT solutions for monitoring machine utilization provide businesses with real-time equipment utilization metrics, thus offering a detailed view of what is occurring at every point of the production process.

Monitoring machine utilization starts with pulling relevant data about machine operating parameters such as run time, actual operating speed, product output, etc. from sensors, Supervisory Control and Data Acquisition (SCADA) or Distributed Control Systems (DCS). The data is gathered in real time and transmitted to the cloud for processing. The cloud aggregates the data and develops it into informative insights about equipment utilization through Key Performance Indicators (KPIs) such as Total Effective Equipment Performance (TEEP), Overall Equipment Efficiency (OEE), set-up and adjustment time, idling and minor stops, etc.). After the data is analyzed, the results are visualized and displayed to the factory workers via a user app (either web or mobile).

Monitoring the quality of the produced goods can be carried out in two ways, either by inspecting a WIP (work in progress) as it moves through the production cycle or by monitoring the condition and calibration of machines on which a product is manufactured. Although quality control based on inspecting WIPs provides more accurate results (it helps to uncover minor defects like inaccuracies in parts alignment etc.), there are certain limitations that hinder the method's usage such as:

- Quality control based on WIP inspection is applicable only for discrete manufacturing.
- It is costly, time- and labor-intensive, as the WIPs are inspected manually.
- It is rarely possible to inspect every WIP, therefore, the method provides a fractional view.

The second method, based on monitoring the condition and calibration of machines, offers less differentiation in terms of scope - it provides simple binary classification "good" and "not good". However, it helps to detect bottlenecks in the manufacturing operations, identify badly tuned and/or underperforming machines, timely prevent machine damages, and the like.

To monitor the quality of the production process, such parameters as equipment calibration, machine conditions (speed, vibration, etc.) and environmental conditions (temperature, humidity, etc.) are monitored to identify when they go beyond the normal thresholds. If sensor readings are approaching the thresholds that can lead to a potential product defect, a quality monitoring solution pinpoints the source of an issue, triggers an alert and recommends a mitigating action to fix or tune the machine and minimize the production of low-quality products.

Safety management is fundamental in any organization. In various industrial sectors like mining, oil & gas, transport, etc., workers receive Radio Frequency Identification (RFID) tags which gather data on their location; and wearable sensors collecting data about their heart rate, skin temperature, galvanic skin response, and other parameters. The sensor data is relayed to the cloud where it is analyzed against contextual data (e.g., from environmental sensors, legacy work planning systems, weather feeds, etc.) to detect unusual behavior patterns (say, sudden vertical movements, unusual heart rates, etc.), and prevent workers from falls, overexertion, and other injuries and timely report a safety threat. For instance, a combination of high skin temperature, a raised heart rate, and no movement patterns for about a minute could indicate that a person suffers from overheating. Whenever such a situation is recognized, an IoT solution notifies an employee's responsible person (a worker's manager, a doctor, etc.) via a mobile application.

IoT Applications for Industrial Asset Management

Along with improving the effectiveness of manufacturing operations, the Internet of Things is applied in manufacturing to ensure proper asset usage, extend equipment service life, improve reliability; and provide the best returns on assets. The IoT applications facilitating industrial asset management include:

- Industrial asset tracking
- Inventory management
- Predictive maintenance (based on condition monitoring).

Industrial Asset Tracking

To enable asset tracking for manufacturing, IoT works together with RFID. Each asset – be it a magnetic locator or a crane gets labeled with an RFID tag, which serves as an asset identifier. Each tag has a unique ID, which is linked to the data about a particular asset. Both the ID and the corresponding asset data is stored in the cloud. The asset data may include the asset's physical parameters, cost, serial number, model, assigned employee, area of use, etc.

Once an asset, say, a crane leaves an equipment storage yard, an RFID reader installed at the yard entrance, scans the tag attached to the crane and saves the record about the asset leaving the yard to an in-cloud database. Similarly, when the crane enters, say, a construction site, an RFID reader at the construction site entrance scans the tag and updates the data in the database. Logging such data throughout the asset's journey allows technicians to see the movements of the assets.

Inventory Management

IoT-driven inventory management solutions help manufacturers automate inventory tracking and reporting, ensure constant visibility into the statuses and locations of individual inventory items, and optimize lead time (the time between an inventory order and its delivery). Due to these improvements, smart inventory management solutions are reported to save 20% to 50% of an enterprise' inventory carrying costs.

Predictive Maintenance

Predictive maintenance relies on the insights gained with continuous equipment condition monitoring. A piece of equipment gets sensors, which collect data on a wide range of parameters determining its health and performance, e.g., temperature, pressure, vibration frequency, etc.

Once collected, the real-time data from multiple sensors is transmitted to the cloud, where sensor readings are combined with metadata (equipment's model, configuration, operational settings, etc.), equipment usage history, and maintenance data fetched from Enterprise Resource Planning (ERP), maintenance systems and other sources. The whole of data is analyzed, visualized, and presented to shop floor workers on a dashboard or in a mobile app. However, mere reporting and visualization is still far from prediction. To enable prediction, the combined data set is run through machine learning algorithms to pinpoint abnormal patterns that may lead to equipment failures.

Data scientists use the recognized data patterns as the basis for creating predictive models. The models are trained, tested, and then used to identify whether any incipient problems take place, predict when a machine is likely to fail, pinpoint operating conditions and machine usage patterns that lead to failures, etc.

Dimension 2: Visibility across the manufacturing supply chain Smart supply chain management solutions provide manufacturers with real-time insights into the location, status, and condition of every object (be it an individual inventory item on a warehouse shelve or a truck delivering supplies) at any segment of the manufacturing supply chain. Along with monitoring the location and the properties of the objects, IoT is applied to monitor the conditions, under which the objects are stored and delivered. Before IoT came into play, the condition of goods could only be monitored once they arrived at the delivery point. Now, the condition of materials, components and goods can be monitored en route, which is especially relevant for the manufacturers of breakable and perishable items (e.g., pharmaceuticals, food, glassware, modern nanomaterials, etc.).

Let us consider an example of a pharmaceutical company shipping an order to a distribution center via a third-party logistics service provider. Sensors attached to the containers monitor the temperature inside the containers. Suppose, because of a cooling system failure, the temperature inside the containers is starting to rise. A temperature sensor attached to the inner side of the container 'detects' the deviation from the recommended threshold. The IoT solution notifies the manufacturer that the delivery conditions have been violated and alerts the driver, who resets the cooling system, thus, preventing spoilage of the transported medicines.

Dimension 3: Visibility into remote and outsourced operations High logistics costs, increasing demand for customization, the complexity of the global supply chain, and the lack of local talent (hence, the need to outsource) demand the shop floor operations to get distributed. When an enterprise builds or buys a manufacturing facility in a different city, state or country it still has to maintain its manufacturing and production standards (material testing, industrial automation, predictive maintenance, and other). Failure to monitor with traditional methods, the compliance with the production standards can be monitored with IoT.

For instance, IoT-based predictive maintenance and timely prediction of potential failures allows scheduling maintenance activities in advance and eliminates the need to keep a local maintenance team. Similarly, IoT-driven utilization monitoring solutions help manufacturers keep an eye on the efficiency of manufacturing operations (by providing real-time equipment efficiency metrics) without direct access to the shop floor.

The Challenges in the Adoption of IIoT

The following are some of the challenges in the adoption of IIoT:

1. Large investment needs and uncertainty about the ROI.

IoT initiatives incur several investments such as spending huge amounts on hardware (sensors, gateways), connectivity, cloud storage, administrative labour and technical support. Businesses have to consider how quickly they can roll out new solutions and how fast it will take for a solution to start generating revenue.

2. Data security issues.

58% of IIoT adopters believe IIoT is increasing the risk of cyber-attacks (but half of IoT adopters claim that they do not have a plan to prevent losses from possible security threats). As IoT devices become more commonplace, the number of IoT security threats is expected to rise.

3. Lack of qualified employees.

It is understood that 72% of businesses have a shortage of people at the management level with experience in IoT. Further, it has been reported that 80% of employees do not possess the requisite skills in IoT deployment. Another research found the specific skills that are lacking, which include analytics expertise and experience in big data, embedded software development, embedded electronics, IT security and artificial intelligence.

4. The integration with operational technologies and legacy systems.

The difficulty of rolling out IoT solutions in the manufacturing ecosystems is integrating Information Technology (IT) and Operational Technology (OT) without data losses and security inconsistencies. Ensuring flawless convergence between IT and OT is difficult because in the past, the systems had different objectives, hence, were built based on different technologies and networks. Today, the fast diffusion of web-based user interfaces is gradually easing the integration process; but the challenge is still to be solved.

Conclusion

Despite the challenges being encountered in the applications of IIoT in manufacturing, the IIoT has been contributing in almost all areas of modern manufacturing processes including supply chain, process control, logistics, maintenance and infrastructure. IIoT would certainly help to improve the efficiency and reliability of the manufacturing industries by reducing the labour cost, energy cost, and optimize maintenance scheduling.

References

1. Aggarwal R, Das ML. RFID Security in the Context of "Internet of Things". First International Conference on Security of Internet of Things, *Kerala* 2012: 51-56.
2. Anita R. Internet of Things (IoT) - Its Impact on Manufacturing Process. *International Journal of Engineering Technology Science and Research* (IJETSR) 2017; 4(12).
3. Bloom G, Alsulami B, Nwafor E et al. Design patterns for the Industrial Internet of Things. In Proceedings of the 2018 14th IEEE International Workshop on Factory Communication Systems (WFCS), Imperia, Italy 2018; 13-15: 1-10.
4. Gershenfeld N, Krikorian R, Cohen D. The Internet of Things. Scientific American 2004; 291: 76-81.
5. Chitha G, Balaji DH, Kavinprabu SSM et al. Review on smart manufacturing based on IoT: An Industrial application. *International research Journal of Engineering and Technology* (IRJET) 2017; 4(116).
6. Rose K, Eldridge S, Chapin L. The Internet of Things: An Overview Understanding the Issues and Challenges of a More Connected World". The Internet Society (ISOC), October 2015.
7. Madakam S, Ramaswamy R, Tripathi S. Internet of Things (IoT): A Literature Review*. Journal of Computer and Communications* 2015; 3: 164-173.
8. Saqlain M, Piao M, Shim Y et al. Framework of an IoT-based Industrial Data Management for Smart Manufacturing. Journal of Sensor and Actuator Networks, Korea 2019.
9. Weiser M. The computer for the 21st century. Scientific American. 1991: 66-75.
10. Lavi Y. Industry 4.0: Harnessing the Power of ERP and MES Integration. Magic Software Enterprises Limited. Published in 'Industry Week'. Endeavor Business Media, Cleveland, Ohio, USA 2017.