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INTEGRATION OF MANUFACTURING SYSTEM WITH INTERNET OF THINGS: A REVIEW

Ajay Sharma[1], Dr. Hari Om[2] and Dr. Sanjeev Goyal[3]

[1]Research Scholar, Department of Mechanical Engineering, J.C. Bose University of Science and Technology, YMCA, Faridabad, 121006, India. Phone: +919996586847,
e-mail: ajay.ace21@gmail.com

[2] Professor, J.C. Bose University of Science and Technology, YMCA, Faridabad, 121006, India.

[3]Assistant Professor, J.C. Bose University of Science and Technology, YMCA, Faridabad, 121006, India

Abstract

The big evolution of information technology as 4th industrial revolution (Industry 4.0),Internet of Things (IoT) has encouraged making factories smart. Reviewing and analyzing the current scenario of the smart factories, here represents a concept of integration of internet on manufacturing system. IoT allows the communication of production data acquisition from the machines with sensor devices. Data can be collected through application installed on mobile devices which is analyzed later and a prediction is made to enhance the productivity of a manufacturing system. As per industry 4.0 using intelligent technology, machines become smart with embedded sensors, have machine to machine communication, capable to make control decision, which contribute to improve productivity in the manufacturing system. This study presents a review on the available techniques of IoT for integration with manufacturing industries.

Keywords: *Manufacturing System, Internet of Things, Sensors, Data Analysis.*

1. Introduction

Industry 4.0 means the application of smart sensors, IoT and big data from smart building, smart city to smart factories. Internet has vast application in various field i.e. banking, business, government offices, agriculture, education, information transfer, service sector etc. Also with the start of 4th industrial revolution, a new term known as internet of things has a great impact on manufacturing sector. According to the IoT adoption, manufacturing system is transformed into Smart Factories in which machines and resources communicate and are inter-connected with a network. To achieve that, machine tools, resources as well as existing IT tools of an enterprise should be connected to the internet directly or through external adapters. In an IoT enabled manufacturing system, data acquisition process performs with the sensors embedded in the machines. Some very important Wireless Sensor Network (WSN) technology i.e. Beacon Technology, Radio Frequency Identification (GF and RV, 2017), makes the connections among the machines(Jia *et al.*, 2012).In smart manufacturing utilization of IoT-enabled data analytics play important role to improve asset utilization and greater efficiency. Combining new and old data with analytics-driven insight will give manufacturing workers the degree of flexibility and decision-making capability they need to deal with increasing market complexity and demand variability. The IoT shows employability to the managers or decision makers in interpreting and forecasting of manufacturing industries. Also, to achieve the potential applications of the new technologies such as Cloud Computing (CC) and IoT in manufacturing have been investigated (Tao, Zuo, *et al.*, 2014).This study provides an overview on the IoT structure of a manufacturing system.

2. Internet of things Architecture

Utilization of technological advancement of computer aided techniques and wireless network, reflects in powerful internet, which is further a boostto the manufacturing system. (Ray, 2018) has reported architecture of IoT to enhance the productivity of production in an industry. The functional elements in an IoT architecture comprised of various utility devices to the system such as, sensing identification, data flow, and data communication through the wireless networks. IoT enabled devices that provide data through sensing, control the monitoring activities.

As IoT has wide range of application from intelligent infrastructure and smart cities to agriculture, logistic and health care, it also has potential impact on factory automation to make manufacturing system more agile and flexible. The IoT@Work architecture follows a layered pattern(Houyou *et al.*, 2012). These layers provide a managing tool to the IoT infrastructure at the lowest layer of devices and networks, and the IoT applications running on top. In between these two, the function groups include management and orchestration functions that deal with configuration and execution of applications on top of resources and services offered in the IoT infrastructure.

The goal of the IoT@Work project to explore the possibilities to ease the configuration and reduces the setup cost and effort for both engineered applications and an improved integration of manufacturing automation components and devices of the production system.

The application of IoT can categorized on the basis of heterogeneity of data, availability of network, and particular coverage area. Someone utilize it to collect the sensor information consequence of service optimization. It involves the internet centric architecture being the main focus while data is contributed by the equipment (Gubbi *et al.*, 2013). In the object centric architecture, the smart objects take the center stage.

In present scenario of manufacturing industries, it has been discovered to identify major need of enterprise system(ES) of modern enterprises. It has found that the limitations of ES are static IT architecture incapable of dealing with all types of changes and uncertainties, unbalanced flexibility of hardware and software systems, rigid and confined boundaries of an enterprise with the barriers for virtue collaboration and the lack of the considerations on system sustainability(Bi, Xu and Wang, 2014). With the research on IoT infrastructure and the opportunities and challenges are invent of adoption of IoT in the manufacturing industry in their ES. It is cleared that the emerging IoT infrastructure provides a support information systems of next-generation manufacturing enterprises effectively. More specifically, for a specific time, particular equipment, data acquisition systems are more than appropriate to be implementing in collecting and sharing data among manufacturing resources. Extensive computing effectively supports mutual interactions among humans and machines seamlessly, and cloud computing utilizes superpower computing resources to provide a solution to a typical complicated decision-making problems at any level and disciplines. IoT generates numerous massive opportunities to advance manufacturing enterprises in achieving better system performances in globalized and distributed environments. However, the application of IoT in ES are at its early stage, more researches are in demand in the areas such as transportation, hospitals, service organizations, modularized and semantic integration, standardization, and the development of enabling technologies for safe, reliable, and effective communication and decision-making.

3. Integration of IoT Techniques with Manufacturing System (MS)

The fourth revolution of industrial system has possible with advance development of information and communication technology (ICT). ICT has accelerated the progress in manufacturing system with data collection and communication, processing, application logic, data analysis and decision making for managing the resources of MS. Many researchers' focuses on the IoT platform and their prototypes developed within the industrial environment. They use the effective technologies such as wireless sensor and actuator networks for controlling the machines and processes(Khaleel *et al.*, 2017). Enabling Business-Based Internet of Things and Services adopts a service- oriented architecture with IoT approach in modern era of MS. Here some technologies are explained for the IoT architecture adoption as Industry 4.0.

For manufacturing and inventory management, production logistics becomes more effective through IoT integration starting from placing order of raw material to the distribution among the shops of shop-floor. It is found that the production logistics synchronization (PLS) mechanism provides a solution to execute the managerial decision for implementation in IoT and cloud manufacturing (CM)(Qu *et al.*, 2016).

3.1 Beacon Technology in MS

Uses of an internet integration of beacon technology in manufacturing system for data capturing is most effective technique. The beacon technology was integrated into an additive manufacturing process, so that real time monitoring can be performed. Each machine was equipped with beacon, which in turn continuously transmits the web address where information on use, diagnosis and even control of that machine is made available(GF and RV, 2017). When approaching a mobile device (smartphone or tablet) that has 'Physical Web' software installed, the device automatically detects the presence of the beacon and open the webpage that provides the information data and controls of the machine associated with the beacon. By collecting data from the shop floor (process, machines etc.) and providing them to decision- makers on real time and at any place, the manufacturing processes can be improved.

3.2 Radio Frequency Identification Systems in MS

It illustrates the prerequisite of Radio Frequency Identification system(RFID) technology for Internet of Things (IoTs). The main advantage of RFID technology is the automated identification and data capture that promises wholesale changes across a broad spectrum of business activities and aims to reduce the cost of the already used systems such as bar codes. All kinds of information of the physical world used in IOT are perceived and collected by the technologies of sensors, wireless sensors network (WSN), tags of RFID system. RFID tags work as transponders (transmitter/responder), are attached to the objects to count or identify(Jia *et al.*, 2012). The main functions of RFID technology are monitoring, tracking, and supervising. Applications of RFID technology include in supply chain management, process control and object tracking management.

It has a number of applications in manufacturing, automotive industry, health care and medicine, agriculture, logistics, military and defense, environment monitor and disaster warning. A RFID based antitheft vehicle immobilizer is a protective device installed in many cars. RFID also holds great promise for the assembly and manufacturing processes of automobiles, in particular, for flexible and agile production planning, spare parts, and inventory management(Segura Velandia *et al.*, 2016). RFID technology not only helps to automate the whole assembly process in which a significant reduction in cost and shrinkage can be achieved, but it also offers improved services to automobile users that include more efficient replacement part ordering and automated generation of maintenance reminders. The benefits that RFID offers to the automotive industry, both to the production process as well as to end users, are visibility, traceability, flexibility, and added security. So RFID is the main component of IoTs.

3.3Cloud Computing and Internet of Things based Cloud Manufacturing

The prior goal of manufacturing system is to achieve the intelligent access, processing, and smart management, of manufacturing resources and capabilities (MRC) in the whole production processes ,to achieve the potential applications of the new technologies such as Cloud Computing (CC) and IoT in manufacturing have been investigated. The relationships and differences among CM, CC, and IoT are investigated and discussed. The applications of IoT are in the workshop, in the enterprise and among enterprises.

To establish smart communication for data at anytime and anywhere, IoT provides sound platform. With the integration of IoT, the manufacturing data (e.g., the information of sound waves, intensity of light, heat energy, voltage, chemical composition, biological information, and position) can be acquired in real time by RFID technique, global position system (GPS), various types of sensors, and other devices. Specifically, by introducing the generalized IoT architecture into manufacturing industry, it can be used to establish the Connection for communication, Computing, and Control of MRC(Tao, Cheng, *et al.*, 2014). A complete connection will setup between machines/ devices and system. And managerial information collected to make automated control decisions in the organization mof the IoT-enabled manufacturing system in workshops.

Therefore, The control of the physical manufacturing execution process, monitoring and recognition starting from raw materials, in-process materials and semi-finished products to the finish products are the main functions of a IoT integrated smart factory. The data recognized and acquired from the IoT enabled machines are the production-related and product-related input of the management information system. Moreover, the automatic control of manufacturing execution activities is the result under the output of the system to the PLC and other controllers. It promotes the integration of the production-related information, the product-related information, and other business management information, as well as the integration of the IoT-based workshop and other enterprise information subsystems. Enterprises can generate their own manufacturing services for the participation into the external supply chain, in addition to the management of the internal supply chain. It results the origin of the local Internet of services (IoS).

An intelligent perception and access of various manufacturing resources access system based on IoT is designed and presented. The key technologies for intelligent perception and access of various resources (i.e., manufacturing resources, computational resources and intellectual resources) in CM are described. The fiber optics sensors used in a five layered manufacturing resource system. It includes resource layer, perception layer, network layer, service layer and application layer (Tao, Zuo, *et al.*, 2014). The detailed information about the position and configuration of various sensors need to be providing to system. After this, user will collect the data and made available for analysis. On the basis of data gathered and analyzed result, user make prediction about the machines and perform a control action.

The researchers have proposed the integration of unique worlds of cloud and IoT. The bonding of their characteristics is often complementary in a system. IoT and Cloud can benefit from their extended capabilities and make an intermediate layer to deal with real world of data. Cloud and IoT innovate the set of smart applications that have strong impact on everyone life(Botta *et al.*, 2016). It includes the smart home monitoring system, smart healthcare, smart energy and smart grid, smart logistics, automotive with smart mobility etc. With the application of integration of Cloud and IoT it is possible to provide effective services via a network of sensors.

3.4Factories with smart connectivity

Now a day, a word smart becomes very popular. Here, it's trying to make correct definition on the term smart with regard to factory(Radziwon *et al.*, 2014). In the revolutionary vision of conventional factories to smart factories, IoT enabled devices plays an important role.

By connecting the mobile terminals with smart objects like machines, guided vehicles, and conveyors makes vertical integration to implement flexible and reconfigurable smart factories. The term vertical integration, define the smart factories that are reconfigurable and flexible to fulfill the production requirement. Many authors focus on developing the general architecture of the smart factory(Wang *et al.*, 2016). Smart hardware and software are required for smart factories, which includes micro controllers embedded machines, high bandwidth wireless networks, big data analytics software/ languages.

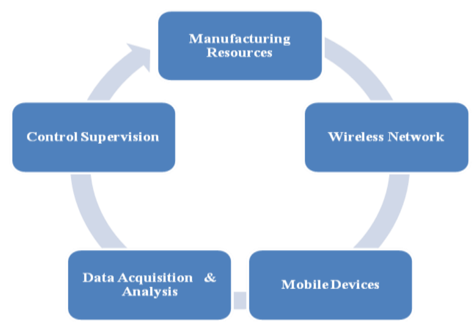

Figure1. Smart Factory Framework

Formation of a dynamic scheduling environment provides a boost to the short- term scheduling in smart factories. This dynamic formation is supported with algorithm of global optimization. The modification of traditional optimal program control (OPC) model keeps updating the complicated constraints with feasible control to fulfill required capacity received(Sokolov *et al.*, 2015). Researchers present the mathematical model for flow control, machine control and control processes of the operations.

Manufacturing industry has been developing innovative advances with the advances of ICT. As many countries like U.S., Korea and Germany, has various strategies and assignments like Distribute proliferate smart factories, Develop smart manufacturing technologies, Reinforce manufacturing soft power, Promote production facility sophistication investment (Kim *et al.*, 2016). They establish IoT platform based development and assistance systems to strengthen the competitiveness of micro and macro industries through the integration of IoT with manufacturing. Many products and services development projects established through the infrastructure of ICT and smart manufacturing services. They suggest the CPS (Cyber-physical System) model for making industry smart through the connection of smart devices with the cloud world.

Authors investigate that adoption of IoT in active manufacturing for three- dimensional printing technology is a managerial approach. IoT produces the data from 3-D printers through data generating devices embedded, which would be stored, formulate and analyzed(Ghoshal *et al.*, 2001). The application of IoT in factories to make smart connectivity can be conceptualize in four general stages. In stage 1, the data generation could be done using RFID tags that are embedded and useful in production of data. Stage 2, all the machine provided with the various sensors to connect them with the internet though RFID tags. Stage3, all the equipment and 3-D printers can be active on internet, equipped with sensing devices and continuously producing data on internet. Stage 4, on the basis of analyzed data results, the production system can be amending to improve the productivity. This makes the manufacturing system as Smart Manufacturing System. In this way factories becomes Smart Factories.

IoT technology enables the smart connectivity of cloud manufacturing and sensing of manufacturing resources. With the integration of IoT cloud platform allows enormous amounts of cloud netizens to present their ideas and solution proposals to the manufacturing system that will be evaluated by decision makers(Ren *et al.*, 2017). According to authors the new technology of IoT and Cloud manufacturing is emerging as a new manufacturing paradigm as well as an integrated technology that can transform manufacturing industry towards service oriented, highly collaborative and innovative manufacturing. There also relationships among Iot, cloud manufacturing, cloud computing and advanced manufacturing models and technologies, especially the relevant concepts and ideas contributing to the evolution of cloud manufacturing.

To achieve smart decision, all the manufacturing resources like men, machines, materials, machine tools and guided vehicles have to connect with smart connectivity. This can be achieved with the use of embedded IoT devices (like sensors, actuators), which track and provide the real time data information. A laser- scanner provides a 3-D data point as a raw data, which can be converted into useful information through 3D building information modeling(Zhong, Xu and Wang, 2017). A systematic architecture of smart factories consists of three major layers. These layers includes, manufacturing resources carrying IoT devices such as RFID tags, communicate with each other and provides large number of data. This large data will processed with several data algorithms such as data editing, data cleansing, and data analysis. This data makes available for iVTP for sharing with others.By introducing the iVTP, RFID tags and laser- scanner in an IoT enabled factory, the efficiency of a production system can be improve.

4. Conclusion

Above study represent the integration of IoT with manufacturing system, many researchers found that this technique as a revolutionary adaptive tool to the production system as per Industry 4.0 scenario. Utilization of RFID tags, sensors, data communication, WSN in additive manufacturing as data generation and data flow for analysis and made available for decision makers. The adaption of IoT in manufacturing system makes factories as Smart Factory.

In current study, it is found that the existing IoT architecture has less impact on manufacturing system due to lack of some architectural knowledge about the technique of IoT, which creates a resistance to the researchers to get familiar with the scope of Internet of Things in manufacturing technology.

There is a need to improve the technological understanding of the related tools and data acquisition techniques to facilitate the IoT development requirements. Also, need to enhance the education and training to develop the architecture for smart manufacturing.

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