Industrial Internet of Things (IIoT): A Literature Review

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Abstract— Industrial Internet of Things (IIoT) is a part of IoT (Internet of Things) technology that has provided an opportunity to build powerful industrial system and applications by using different IoT devices like sensors, actuators, Resistance Temperature Detectors, pH analyzers, Level Transmitters, RFIDs, wireless and mobile devices. High-speed internet has given a new hike in development of IIoT devices, as it makes remote access facility at ease. Various IIoT applications and systems have been developed and deployed in recent years. To understand the development of IIoT technology, this study addresses IIoT concepts through a systematic review of various white papers, research papers and online database. This paper will provide an overview of IIoT technology, key enabling technologies and their applications in industries.

Keywords: Actuators, IIoT, Industrial internet of things, Internet of Things, IoT, LT, RFID, Sensor

I. INTRODUCTION

The Industrial Internet of Things was initially adopted by industries as a way to improve operational efficiency. But in today's environment, it can improve the overall efficiency of industries in terms of productivity, quality, cost, delivery, safety and morale. The IIoT has significantly changed the working of industries, whether it is the detection of predictive maintenance of any drive or it is a real-time monitoring of any process parameter. IIoT devices helped industries to carry out many activities safely which previously were identified as accident-prone like acid tank level checking, corrosion detection inside a refinery pipe etc. IIoT technology not only applies to manufacturing, mining, oil, gas, agriculture and utility industries but also in hospitals, warehouses, transportation, logistics, ports and banking sector. There will be worldwide spending of $500billion by 2020 on IIoT technology as every industry wants to use IIoT technology because, by introduce IIoT in industries, manufacture can boost their productivity by 30 percent and can reduce overall maintenance cost up to 30 percent, which can further eliminate breakdowns up to 70 percent[1].

II. INDUSTRIAL INTERNET OF THINGS

Industrial Internet of Things phrase consists of three different words, i.e. Internet, industrial and things. The "Internet" is a global computer network consists of millions of public, private and government networks while "Things" are objects embedded with electronics, sensors and software. By combining these two words it becomes a network of things embedded with software, electronics and networking capability through which these objects can collect and exchange required data. This is known as "Internet of Things". When IoT applied in manufacturing it is known as "Industrial Internet of things". This technology is a combination of different technologies like M2M communication, machine learning, big data, sensor data and automation; those are already existed in industries [2]. Some of the well-known examples of IIoT technology are- robotic arms for lifting or shifting materials, temperature sensors and level indicators etc. IIoT is a transformative manufacturing strategy that helps to improve productivity, quality, safety and delivery in an industry and manufacturers are increasing uses of IIoT solutions to enhance their analytics functionalities, to track assets and to upgrade their control rooms [3]. The global industrial IoT market is expected to reach USD 933.62 billion by 2025[4] and estimated potential economic impact will be $4 trillion to $11 trillion by 2025[5].

III. DEFINITIONS

There are many different groups including academicians, researchers, developers and corporate people those have defined IIoT, but still, there is no unique definition is available for IIoT, which has been accepted by everyone. Some of the important definitions of IIoT are discussed here. According to GE digital group, IIoT brings together machine, man and advance analytics. It is a system of connected devices which can monitor, collect, analyze and exchange valuable information. This information can be used by industries for taking faster action based on their business need [6]. According to inductive automation, IoT is a network of devices, computers and object that can share data and sent to cloud-based service where it is analyzed and shared with end users in a helpful way, and application

 DOI : 10.18231/2454-9150.2018.0340

of these IoT devices in manufacturing industries is known as IIoT [7]. According to IoTAgenda IIoT incorporates existing industrial technologies like machine-to-machine communication, sensors, and automation technology with big data and machine learning [8].

The Best definition for IIoT would be: "Networks of industrial usable intelligent objects that can obtain, share, and analyze information to act upon a situation in a manner that is required by its user."

IV. KEY ENABLING TECHNOLOGY

IIoT is developed from the intelligent integration of several existing technologies. In this section, several technologies their applications and integration with other technologies discussed briefly.

A) Cloud Computing – Cloud computing provides computing, on demand of users as a service. It can provide platforms, infrastructure and software as a service. Since sensors have limited memory and processing power it can only store and process local data. Cloud also allows IoT applications to monitor and analyze all the objects. It also supports artificial intelligence for the decision, thus bypassing human intervention.

B) Big Data – Big data is the term used to represent a large amount of data on which normal data processing application are unable to perform data related operations. Some special techniques like Hiveql and Hadoop used to manage these large volume data in Big data. Big data is very useful in many areas, like social networking, research fields, in governments etc. In IIoT technology, a large amount of collected information is supported by cloud computing, when combining this with big data, it provides an excellent support to retrieve and store useful information.

C) Ubiquitous Computing – The main objective of the ubiquitous computing is to include invisibly embed technology in the environment. Mark Weiser (father of ubiquitous computing) defines ubiquitous computing as "the physical world that is richly and invisibly interwoven with sensors, actuator, displays and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network"[9]. The goal of IoT is to sense the environment without the intervention of human and ubiquitous computing is a way to achieve this goal.

D) Smart Devices – A smart device is an electronic device, which can operate to some extent autonomously and generally connected with other devices or networks with the help of different protocols like Wi-Fi, 4G and Bluetooth etc. Some examples of these types of devices are smartphones, tablets, smart band and watches. IoT technology uses many of these devices to gather and analyze information.

E) Sensors and Actuators – A sensor is a device which converts one form of signal to another form which can be measured. Types of sensors are temperature, proximity, vision, gyroscope, compass, acceleration/tilt etc. The actuator is a hardware device which converts the command into physical change, this change is mostly mechanical. (E.g. position or velocity)

F) Artificial Intelligence (AI) – Human or animal-like intelligence shown by machine is known as artificial intelligence. In IIoT it is shown by smart objects. (e.g. sensors etc.) Due to this intelligence nowadays machines can alerts before any unwanted situation occurs or they can take necessary actions based on their applications in different types of industries.

G) RFID (Radio Frequency Identification) – RFID technology is used to monitor objects. This system has mainly two components, RFID reader and RFID tag. RFID reader starts communication with a tag by sending a query to RFID tag to identify it. RFID tag is a small chip with an antenna and associated with a unique ID. [10] This tag can be attached to any object which needs to be tracked. There are two types of RFID tags are available. One is passive RFID tags which don't have any battery. It takes power from the query signal transmitted by the reader while another one is active RFID which contains a battery. It can communicate by transmitting its ID. It is mostly used in industry's store to track objects.

H) GPS (Global Positioning System) Technology – GPS is a network of satellites which was originally developed by the US government for their military, but now anyone with a GPS device can receive signals from these satellites. GPS uses a process known as trilateration when it has information about at least three satellites to pinpoint the location. This technology is used in logistic departments of industries.

I) Advanced Robotic and Automation Technology -- A robot can be defined as an automatic, controllable, reprogrammable, multipurpose intelligent machine which can be programmed to do such tasks those consumes time or manpower. Automation is the use of various control technologies for operating equipment such as machines, turbines, ovens, boilers, heat exchangers, processes in industries etc.

J) Wireless Sensor Networks (WSN) – Wireless sensors are used for sensing and controlling environmental parameters. Each sensor consists of the sensor interface, small memory and processing units, transceivers, converters for analogue to digital and vice versa [11]. These sensors can sense, communicate with other sensors

 DOI : 10.18231/2454-9150.2018.0340

in the environment and can process data. Many such sensors combine to form a wireless sensor network.

K) Wireless Fidelity (Wi-Fi) – Wireless Fidelity (Wi-Fi) is a type of networking technology that facilitates wireless communication among computers and other devices. Vic Hayes is known as the father of Wireless Fidelity. Many devices now have inbuilt Wi-Fi and can be connected to the internet using WLAN. Wi-Fi commonly uses 2.4 and 5.8 GHz radio band. Wi-Fi is more vulnerable to attack than a wired network.

L) Bluetooth – Bluetooth technology is short-range radio technology that does not need cabling to transfer data. In 1994 Ericson Mobile Communication company started a project named "Bluetooth". It is mostly used to create Personal Area Networks (PAN) for data sharing by connecting 2-8 devices at a time. The IEEE standardized Bluetooth as IEEE 802.15.1, but now it does not maintain this standard anymore.

M) ZigBee – ZigBee was developed to enhance the features of wireless sensor networks and created by the ZigBee Alliance. Features of this protocol are low data rate, shorter distance, scalability, flexibility and reliability. Its working range is around 100 meters with 250kbps speed. This protocol mostly used in home automation, medical, agricultural and in industries.

N) Barcode – Barcode is machine readable, optical, numbers and letters encoded by a combination of varying width bars and gaps. Barcode is machine-readable labels attached to the physical product and contain information about a product like product description, price, unit of measurement etc. There are mainly two types of barcode available 1D and 2D. The 1D barcode contains less information than the 2D barcode.

V. APPLICATION OF IoT IN INDUSTRIES

IoT technology is now being used in industries on large scale. In this section, some major applications of IoT technology are discussed briefly.

A) Smart Factories– IIoT enabled equipment can sense the environment and transmit data to managers or field engineers, which enable them to remotely manage their factory units and take advantages of process automation. IIoT devices can also transmit data regarding production, losses and inventory to their managers so they can take timely necessary actions.

B) Maintenance Management- IIoT sensor enables condition-based maintenance by monitoring critical machines and alerting managers when they deviate from specified parameters like temperature or vibration ranges. This functionality reduces breakdown time, cost and increase operational efficiency of the plant.

C) Process Management- IIoT in manufacturing industries enables monitoring of refining process of raw material to packaging of the final product. This nearly real-time monitoring enables production managers to adjust plant parameters so production targets can be met with quality and cost.

D) Inventory Management- IIoT permits monitoring of each and every supply chain events from material arrival to material dispatch; any deviation from the plan can be captured by managers in real time, so they can act upon accordingly. IoT device RFID and barcodes are used in stores for material management which reduce a significant amount of time and energy consumed by human-based inventory management system.

E) Quality Control- Uses of IIoT in the production line can improve the overall quality of the final product as they can monitor process and equipment on real-time and maintain plant parameter like temperature, pH, acidity, impurity, densities etc. in a range which results in a quality product. They can also monitor third party raw material quality and can capture customer reviews on final product which can be later analyzed for quality issues.

F) Safety and Security- IIoT devices can work in a hazardous environment like in acid plant or in confined space, thus reducing or eliminating human life intervention. IIoT devices themselves can take immediate actions based on their area of application viz. stopping furnace if the temperature goes beyond the specified limit, honk a siren if the boiler is going to explode or a stack is going to fall etc. Overall workers safety can be enhanced by using big data and IoT technology.

G) Logistic Management- IIoT can provide nearly real-time tracking information of raw material, the final product, plant equipment and their spare parts. This information will help managers to predict issues and their resolutions in time. GPS enabled vehicle monitoring system can help manufacturers to track raw material availability and final product's delivery in time.

VI. CONCLUSION

IIoT is the developing technology that is going to change the working of industries completely. Since IIoT is going to occupy every industry in future, it is necessary for us to understand IIoT technology and its uses in the industry. IIoT emerges from the collaboration of many existing technologies and now it is being used with big data, sensor data and cloud computing to reduce manual overhead in a cost-effective manner. Technologies such as sensors, actuators, RFIDs and embedded systems play a vital role in forming IIoT applications as they are getting increasingly powerful, less expensive and smaller. Industries are using IIoT technology to deploy automated monitoring, maintenance of equipment, process management, logistics

 DOI : 10.18231/2454-9150.2018.0340

management and inventory management. Though this technology is in demand, still it faces some critical issues like privacy and security, which need to be rectified. As IIoT is multi-perspective and has several definitions in a different perspective, this paper tries to give clear vision about IIoT technology, its definitions and uses in industries after reviewing various research papers, white papers and online database.

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 DOI : 10.18231/2454-9150.2018.0340