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INTERNET OF THINGS: TECHNOLOGIES, IMPACT ON MANUFACTURING AND APPLICATIONS

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ABSTRACT- Internet of Things (IoT) is a network of physical objects with embedded technology which are connected and exchange information with each other. This is a new promising technology as it represents forth industrial revolution and it can be useful in many domains and various industries such as manufacturing industry, health care industry, mining industry, food service industry, transportation and logistics domain. This paper discusses the concept of IoT technology, key enabling technology of IoT that are Identification technology, sensing technology and communication technology with a review of current stage of research and application of IoT in different industries and domains and how it can change the traditional production system. The possible impact of IoT on different aspects of manufacturing has also being presented.

Keywords— Internet of Things, RFID, Enabling key Technologies, Impact of IoT on manufacturing and Application

I. INTRODUCTION

The Internet of Things (IoT) is a network of objects which are connected via internet and can exchange information or communicate with each other. The term IoT was first used by Kevin Ashton in his presentation at Proctor and Gamble (P&G) in 1999. He linked Radio Frequency Identification Device (RFID) in P&G's supply chain. Initially the IoT term referred to those objects which were connected through RFID technology [1]. Later on many technologies like sensors, actuators, mobiles, cloud, internet protocol and many more were added to this technology. Today the definition of IoT which is commonly accepted is "a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'Things' have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network." [2] IoT is an evolving technology which provides solution to the industrial problems and can transform their existing manufacturing and transportation system into intelligent one. For example, In IoT enabled transportation system the authority can track the vehicle's location, its movement and able to predict its location in near future [3] and, in intelligent manufacturing system an engineer can monitor the status of shop floor.

II. LITERATURE REVIEW

Internet of Things (IoT) is a relatively new field and limited literature is available about its concept, structure, its applications in various fields, and the related technologies.

What is IoT

A number of researchers have presented the layout, the structure of the IoT and how IoT can be applied in various industries to increase their productivity, and day to day life to increase the standard of living.

Miorandi et al. [4] presented the vision of Internet of Things (IoT), research challenges which it faces in today's world. Study revealed that IoT can connect the physical world to the digital world with the help of information and communication technologies, and can be employed for a variety of applications and services. The vision of IoT is based on the ability of the smart devices to become identifiable to a network and can communicate or interact with the network or with other smart devices. Since the smart objects use the information to communicate and the information is generated by the sensors so we need a large number of sensors to cover an IoT network, which is the first research challenge for an IoT network another challenge for the implementation of the IoT is, the security and the confidentiality of the data and the privacy of the information. The applications of IoT are in development of smart home which can switch on/off the lighting, smart cities with advanced control of traffic system, environment monitoring, healthcare, smart business, security, and surveillance.

Mourtzis et al. [5] suggested that the implementation of IoT in manufacturing industry can generate massive data which is being called big data and in the context to industry, industrial big data. With the use of sensor embedded machines in today's industry, the data generation rate has increased. The data generated by sensor embedded machine tools, cloud based solution as well as business management has already reached a total volume of more than 1000 Exabyte annually. The main goal of adopting the IoT in the industrial sector is to connect all the machines to a network with the help of adapter so they can communicate with each other. The study presented a monitoring tool which consists of data acquisition (DAQ) device and a central gateway which coordinates the transmission of data and also collects the data from the DAQ and organize the data into packets before transmitting to the cloud.

Zhou et al. [6] presented the plan of Germany to implement the Industry 4.0 standard, which consists of four steps- First is building a cyber-physical system (CPS) which connects all machines or devices to a network. CPS constitute of five functions like computing, precision control, communication, coordination and autonomy. Second step is to researching two themes one is smart factory theme and other is intelligent production theme. The first theme focuses on the intelligent manufacturing system and the second one focuses on the interaction of human with the computers. Third step is the realization of horizontal integration, vertical integration and end to end integration. Fourth step is to achieve some planning objectives like efficient management, safety, and security, organisation of work, and establishment of regulatory framework. This study also discusses the key technologies which are, the formation of the cyber-physical production system (CPPS) by using CPS technology, mobile internet and IOT technologies and cloud computing & big data. This study also discusses the challenges for the industry, since each industry deals with different devices so it is difficult to develop the smart devices each have different configuration it is the first challenge for implementation of industry 4.0 the second challenge is to construct the network environment which has different systems and then modelling of CPS systems.

Yang et al. [7] discussed some core technologies of Internet of Things like radio frequency identification devices, wireless sensor network (WSN), cloud computing and big data The function of RFID is to transfer the data by using electromagnetic fields. Wireless Sensor Network (WSN) are composed of autonomous nodes that can sense the environment, conduct computations and communicate with the other nodes. Cloud Computing which enables the efficient management of an extremely large shared pool of networks that can be rapidly provisioned and released with minimal management of effort. Big data is used to refer the large amount of dataset. The study also explain the research issue of IoT enabled manufacturing which are reference architecture, deployment and business model, manufacturing big data, cyber physical models and simulation etc. the paper also discuss the application of IoT in automation and efficiency, in energy management, proactive maintenance, connected supply chain management.

Zang et al. [8] presented a solution in the form of Real Time Manufacturing Information Integration Services (RTMIIS) to the challenge to transfer information between heterogeneous. The study also discussed the architecture of Internet of Manufacturing Things (IoMT) which consist of four components these are configure the smart manufacturing objects to increase the sensing capability of manufacturing resources, sensing the primitive event and record or capture it, process the insignificant manufacturing data into meaningful information regarding manufacturing process and , and last component is application services. Study also discussed the methodology how to track and trace the two types of manufacturing activities one is manufacturing operation and other one is material logistic with the help of RFID tag and readers.

Tao et al. [9] investigated the application of IoT technologies in Cloud Manufacturing (CMfg) to achieve intelligent perception and access of various manufacturing resources. The different types of manufacturing resources like hard manufacturing resources (all kinds of equipment, raw and processed materials), Computational resources (all kinds of software required, servers, and memories like flash card, micro hard disks), Intellectual resources and other resources which involved in entire life cycle of manufacturing, were also discussed. A five layered structure which consist of resource layer, perception layer, network layer, service layer and application layer was also presented and designed. It is a structure of resource intelligent perception and access system which is based on IoT.

Chen and Jin [10] discussed architecture and concept of IoT which consist of five layers these are sensing layer which captures the information sent by various sensors and other connected devices, the access layer which transfer the information collected by the sensing layer through wireless network to the network layer, the network layer integrated the information available on the network into the large network with internet platform, the middleware layer manage and control the network information in real time and application layers. The enabling key technologies are also discussed such as RFID (Radio Frequency Identification) technology, EPC (Electronic Product Code) and Zig Bee Technology.

Miraj et al. [11] reviewed the importance and future possibilities of Internet of Things (IoT), Internet of Everything (IoE) and Internet of Nano Things (IoNT). The IoT is a network of connected objects to a network on which they can transfer the information and further the information can be analysed by some cloud computing techniques. IoE is a network of data, process, people and things. Whereas IoT is only focused on things. IoE established the communication not only between machine to machine (M2M) but also between person to machine (P2M) person to person (P2P). IoNT is the

fully extended version of IoE in which nano sensors are used. The IoNT has wide application in the medical field to access those areas of human body which is not accessible by normal sensors due to their large size. IoNT can be used to cure the incurable dieses.

Enabling key Technologies of IoT

It is possible to actualise the concept of IoT in real world. This can be done by integrating some enabling key technologies. This section discuss the some of the relevant technologies which are used in IoT framework.

Identification Technologies

Most commonly used identification technology in IoT is Radio Frequency Identification System (RFID). The RFID technology first introduced in 1945 as a tool for Soviet Union to retransmitted the radio waves with some information in audio form. This technology is also used by United Kingdom in World War II for identification of the aircraft as friend or enemy. The RFID system is consist of one reader or more readers with many RFID tags. The RFID tag is define as "It is an automatic technology and aids machines or computers to identify objects, record metadata or control individual target through radio waves" [12]. These tags can be characterized with a unique identifier. The reader and the tags communicate with each other via radio waves the tag generate a radio signal and the signal is then read by reader. The reader generates an appropriate signal which trigger the tags in the surrounding area [13].

RFID system can be used to get the real time information of the object and this technology can mapped the real world into virtual world. The RFID tag is a small microchip which is attached to an antenna that is similar to an adhesive sticker. RFID technology can be categorised in to three types: Passive RFID, Active RFID, and Semi passive RFID [14].

Sensing Technologies

Sensors is a crucial part of IoT network. Sensors can be used with the RFID technology to get real time status of location, movement and temperature. Sensor technology consist of a network of sensors, where each sensor represented as a node and has a wireless communication. A network of these sensors is called wireless sensor network.

Christin et al. [15] evaluated the techniques which integrate Wireless Sensor Networks (WSNs) and internet and outlined the challenges for this integration in near future. The integration of the WSN and internet can be done in two ways 1) Independent network in which a single gate way connect both independent WSN and internet, 2)Hybrid network, still WSN and internet are independent but some sensor nodes can access the internet.

Mourtzis et al. [5] discussed a case study of a company which had 100 machine tools and 150 employees. Each machine tool was equipped with sensor and the data which was generated by the sensors was captured and measured. The volume of data is around 204GB per day, 6TB per month, in context to a year it is 72TB which is a massive data generation rate.

Communication Technologies

The communication technologies such as WiFi, Bluetooth, LTE, IEEE 802.15.4, and Near Field Communication (NFC) which connect heterogeneous system to provide smart services. IoT network mainly use these protocols for connection they are WiFi which uses radio waves to exchange data between objects which are in 100 meter range. Bluetooth uses short wavelengths to exchange data between objects which are in short distance. LTE-Advanced is a wireless communication for data transfer between mobile phones at high speed. IEEE 802.15.4, Z-wave. Near Field Communication (NFC) deliver data transfer at a rate upto 424 kbps it works at high frequency band [16].

III. POSSIBLE IMPACT OF IoT IN MANUFACTURING

It may be inferred from that literature that in manufacturing industry, IoT will change the traditional production system. With the use of sensing technology the performance and productivity of the production system can be increased. Sensors will monitor the whole production process from the inspection of the raw material to the final manufactured product. All these information gathered from the sensors will be stored in a cloud. From the cloud these information may be made available to the shop floor department, inspection department, research and development department, managerial department and any other stake holder throughout the world. For the companies having plant at multiple location, IoT will help to compile the data in real time. The information will be helpful for developing the future planning, forecasting of the product, understanding the current trend. IoT technique can speed up the production system by using real time monitoring of the system which will minimise the deviation from the standards. The root causes for deviations can be easily identified. In IoT enabled production system staff at every level can access the data and tools from a single portal. .IoT will play a major role in latest CAD/CAM integration by providing the CAD model to the machines even remotely, which will help in quick adaptation to the changes in product design. It is foreseen that IoT is going to play a major role in the future of manufacturing.

IV. **APPLICATIONS**

IoT can be applied in various industries like manufacturing, health service, food and domains such as transportation and logistics domain, smart environment (home, office, plant) domain, personal and social domain. But still the IoT applications are in its initial phase. Here are some applications of IoT.

IoT in healthcare service industry [17] IoT can play a vital role in the health care industry. With the use of enabling technology of IoT like identification, sensing and Communication, the temperature of the medicine can be tracked and monitored since the temperature plays vital role for storage and transport of the medicine. Various health care information like diagnosis, recovery therapy, medication, finance, management, and even daily activity can be collected. The Internet of Nano Things is a extended version of IoT in health care in this technology the size of sensor is reduced to the nano scale and then inserted in the body. This technique is a revolution in the health care industry because extended the reach of the medical instrument in body parts.

IoT in food service industry [18] today's food service industry is much dispersed and complex. It has a large number of shareholders and complex operation procedures. This complication affects the food safety, quality management and operational efficiency. IoT can solve this complication by offering the traceability, controllability and visibility. IoT can cover the food service industries in the farm-to-plate manner, in which from accurate agriculture, to food production, food processing then storage to distribution, and consuming. More accurate and efficient, sustainable food service industries can be expect in the future.

IoT in safer mining [19] safety in underground mining is now a days is a serious concern for many countries. To eliminate and reduce misfortunes in the mining, there is a necessity to apply IoT technologies which can sense the mining disaster signals to make warning, disaster forecasting, and safety improvement of underground production possible. Another application is the use of biological and chemical sensors for detection of the early disease and its diagnosis for underground miners, as they work in a dangerous environment. These sensors can be used to obtain biological information from worker's body and organs and to detect hazardous harmful gases, dust and other environmental hazards that will cause accidents.

IoT in Transportation and logistics domain [20] IoT can play crucial role in the domain of transportation and logistics. As physical objects growingly equipped to bar codes, Radio Frequency Identification (RFID) tags, transportation and logistics industries can conduct real-time monitoring of the movement of vehicles from a starting point to a final destination through the complete supply chain together with manufacturing, distribution, shipping, and so on. Furthermore, IoT is likely to propose capable solutions to transform transportation systems and automobile services. As vehicles have progressively powerful sensing, networking, data processing and communication capabilities, IoT technologies will be used to improve these abilities. For example, IoT technologies can create a network which can track every vehicle' location and monitor its movement with prediction of its future location.

V. **CONCLUSIONS**

This paper presents a review on literature published in the context of Internet of Things. The literature review discussed in detail the concept of Internet of Things (IoT) that is it is a network of connected objects which can communicate with each other and exchange the information. IoT is a revolutionise concept that can transform day to day life and industries like never before. In manufacturing industry, IoT represents fourth industrial revolution also known as Industry 4.0. The research paper also discusses the enabling technologies such as identification technology, sensing technology and communication technology which are the important components of the technique. Paper also discusses the applications of the IoT in industries such as manufacturing, health service, food and domains such as transportation and logistics, smart environment (home, office, and plant), personal and social domain. Hence it may be concluded that IoT is going to play a major role in the future of manufacturing.

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