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Iot Based Industrial Automation using Zigbee Communication Standard

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Abstract: ***The current industrial revolution is the industry 4.0. One of its main aims is the replacement of old communication that uses wired links with new communication that is wireless communication. The main reason to move to wireless communication is to improve the mobility, reduce the deployment cost, reduce cable damage and to improve the scalability. To do this, the type of industrial application needs to be taken into consideration. The proposed communication protocol must support low loss rate and must be robust. This is one of the main challenges faced by industrial automation due to interference with other communication devices and reflection with metallic objects in industries. The current industrial revolution is the 4.0 industrial revolution which combines different technologies such as Internet of Things (IOT), robotics, virtual reality and artificial intelligence. The second aim of this paper is to connect devices to IOT so as to improve the accessibility of the industry from anywhere in the world. Apart from communication protocol and IOT, the other services running simultaneously are web browser, email, video or other services. These services are known as Best Effort services. So this communication protocol not only improves power efficiency of the sensors but also it runs the Best Effort services. The proposed protocol to be used is ZigBee communication protocol along with the IOT service. IOT connect anything on the internet using a specified protocol with sensors, devices, equipment to transfer the information & to communicate among devices intelligently to achieve smart monitoring and administration.***

Keywords: IOT, ZigBee communication, Industrial automation, Industry 4.0, low power, Best Effort Services.

I. INTRODUCTION

Industry 4.0:

The industry and technology is changing rapidly around us. Industry 4.0 is the latest industrial revolution taking place right now. In this, the man, machine and the production work intelligently with each other [1].

In industry 4.0 which is also known as smart factory the sensors and smart digital devices are connected and they communicate with each other intelligently. The communication is between raw material, semi-finished product, tools, robots, etc. Industry 4.0 has greater flexibility, efficient resources usage and involvement & integration of customers and business partners in the business process.

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Artificial intelligence plays important role when compared to the robots and men. The sensors which are embedded into the robots respond to the slightest changes in the value.

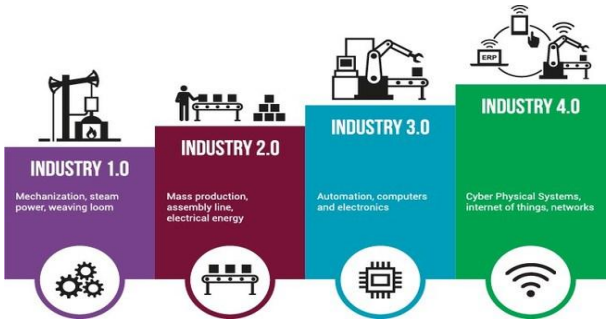

Figure 1. Industry 4.0 revolution [2]

Digital technology has a very high impact in the business model. Digital innovation leads to improved business model. The production department has to be more flexible to convert innovation into a reality. Hardware and software are two critical factors which makes this possible for the real-time evaluation of data. Increasing productivity is one of the main objectives which is done by shortening the time period between the new product development and its delivery period to customers in the market. Other objective include efficiency and energy saving. Efficiency is obtained by automation which leads to quality of product and efficient production. By switching the robots off during waiting for material processing saves electricity drastically to deal with the competitiveness in the global market.

Internet Of Things (IOT):

The Internet Of Things term was introduced in the year 1999 when radio frequency identification development was taking place. It has become more popular with the development of mobile devices, embedded devices, ubiquitous communication, and cloud computing and data analytics [3]. Using IOT many different sensors sense the data, communicate and share information with all this devices which are interconnected over the internet. This interconnected devices and sensors have data collected regularly. This data is analyzed and initiate decisions to make intelligent decisions and intelligent management for planning the production etc. This is made possible by IOT.

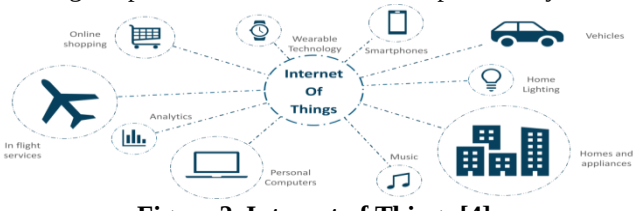

Figure 2. Internet of Things [4]

IOT is defined as "Network of physical objects". Internet consist of not only computers but also network of devices of different types such as smart phones, home appliances, people, etc. all sharing and connected with each other through internet to achieve smart monitoring, online upgrade and smart administration [5,6].

We can also define IOT into three different categories as connection of (i) People to people (ii) People to machine/things and (iii) Machine/things to machine/things connected through internet.

In IOT, general things such as everyday-devices, which are locatable and addressable through internet are connected through the communication means such as RFID, wireless LAN, WAN, etc. Everyday devices not only include equipment but also things which are not electronics such as food, clothing, animal, water, etc. [5, 6].

The aim of the Internet of Things is to connect anything anytime and anyplace using communication protocol and network to any service.

ZIGBEE:

ZigBee is a set of rules for a high level communication protocol that uses small, low-power digital radios based on IEEE 802 standard for personal area network. ZigBee data rate is 250 Kbits/sec. It is best suited for periodic or irregular data from sensor to a microcontroller etc. ZigBee is a low-power and low cost standard that uses mesh network. Because of its low cost it is widely deployed in industrial automation. Because of low power usage the life of battery of sensors improve tremendously. High reliability and extensive range is provided by mesh networking. ZigBee vendors provide microcontrollers and radios between 60 KB and 256 KB flash memory.

The ZigBee network also supports star and tree along with mesh network. The need for ZigBee is. (i) There are many standards that discuss about high data rate for using PC LAN, etc. But still now they did not meet the requirements of sensors and devices. Sensors and control devices need low energy consumption for long battery life. (ii) There are proprietary wireless systems in the market that don't require high data rates but require low cost and low current drain. (iii) Legacy system has interoperability problems with each other and with emerging technologies. That is why this technology is needed.

II LITERATURE REVIEW

INDUSTRY 4.0

The main components of Industry 4.0 are IOT, Cloud based manufacturing and smart manufacturing which will transform manufacturing process into intelligent one [7] [8]. The main characteristics of Industry 4.0 will transform industry into integrated, automated production. This integration will lead to efficiency and change in traditional production methodology among human and machines.

2.1 Big Data: The comprehensive collection of information from different sensors and production equipment will be used to take real-time decisions [9]. As per Forrester's definition big data consist of (i) Volume data (ii) Variety Data (iii) Rate of generation of new data and (iv) Value of Data [10]. The occurred mistakes in the industry are recorded and is used for forecasting and also making the system work smoothly [11].

2.2 Robots: Nowadays robots are becoming more flexible and work closely with human intelligently [9]. Robots are working in harsh places where human cannot work and take intelligent decisions. Robots can perform the task precisely and within a time limit.

2.3Simulations: Using simulations we can make out how the real time system will work before building the real system. This will also lead to improvement in the quality. Simulations not only shorten the time for designing but also reduce the production failures. Decision making can be improved by using it.

2.4 Industrial IoT: In IoT different object are interconnected worldwide using a communication protocol [12]. It consists of Internet of Services, Internet of Manufacturing, Embedded System, Connection to People, and connection to Information and Communication.

2.5 Cyber Security: With the increased use of internet in industy 4.0, the internet attacks have increased tremendously which are thereat to industrial system. We need reliable communication system to overcome this threat [9]. The connection between industrial system, services and the internet gives rise to good information for planning manufacturing system [13].

2.6 Cloud Computing: The industry connects to the cloud based IT platform for communication. Data sharing has increased tremendously in industry 4.0 across companies. This leads to communication within milliseconds or in microseconds. In cloud computing different devices connect to the same cloud and share information which will be helpful for the entire plant [14]

Internet Of Things

The characteristics of IoT are [6,15]

1) **Interconnectivity:** IoT can be connected to anything from anywhere in the world for intelligent decision to be taken in industry or other application.

2) **Heterogeneity:** Different device and sensors are connected to the IoT and they form heterogeneous group. They can communicate with other devices and groups to form a intelligent decision.

3) **Scalability:** The number of devices connected is large when compared to the traditional internet. The amount of data generated is enormous. This data is utilized to improve the functionality of the industries and hence scalability is not a problem with IoT.

4**) Dynamic**: The number of sensors and devices connected changes dynamically. Some sensors and devices go to sleep and wake up after sometime according to requirements.

5) **Connectivity**: Network connectivity become accessible due to connectivity. Due to this the network becomes assessable and compatible to produce and consume the data.

6) **Safety**: Along with benefits comes the safety issue. When IoT system is designed, we must consider the safety of the application. Safety includes the safety of the human-beings and safety of the industrial data. Securing the data and network will secure the entire system.

Application of IOT:

There are enormous applications of IOT. It is useful for individual, industries and Cities. IOT constitutes of smart environment such as City,

Industries, Transportation, Homes, Agriculture, Healthcare, Tourism, etc. Some of the applications of IOT are

A Smart Cities:

Structural Health: Sensing of vibrations and conditions of material of bridges, historical monuments, palaces, etc.
Street Lighting: Intelligent street lights which depends on the condition of the environments.
Safety: System such as fire monitoring, public announcement system are monitored by IOT.
Transportation: Smart Roads signaling such as construction of new roads, diversion of roads as per weather conditions and traffic jams.
Smart Parking: With the crowding of parking areas the smart parking help citizens find parking lot.
Waste management: Sensing of garbage levels and collecting according will improve the cleanliness of the cities.

B Smart Environment:

Air Pollution Monitoring: Pollution emitted by cars, factories, etc are measured and analyzed by air pollution monitoring system.
Forest Fire Detection: Alarms were given once fire takes place in forest. They are detected by IOT based system.
Weather Monitoring: Weather is monitored and Typhoons etc. are monitored by IOT based system. Excessive rain conditions, high temperature conditions are monitored by this system.
Water Quality: Water levels and water quality is checked periodically to access the water conditions.

C Smart Industry:

Explosives and Hazardous Gasses: Using IoT the gas level leakage inside industries, inside chemical factories and mines, etc can be monitored. And also the water level, oil and gas level in storage tanks can also be monitored.
Maintenance and Repair: by sensing the failure and health of the machines, devices can be monitor so that they can be replaced before failure of the device by forecasting.

D Smart Health:

Patient surveillance: Monitoring of old people health by using different sensors and also the conditions of patients indise hospital by using smart devices, etc.
Medical Fridges: Storing of medicine in the cold places and their safety.
Fall Detection: Felling of old people can be detected by using IoT.
Physical Activity Monitoring: Small motion like breathing and heart rate can be sensed by using different sensors as the body of the patient etc.

ZigBee:

ZigBee Devices: There are three different type of ZigBee devices (i) ZigBee Coordinator (ZC) (ii) ZigBee Router (ZR) and (iii) ZigBee End Devices (ZED)
(i) **ZigBee Coordinator (ZC):** It forms the root of the network tree and connect to the other networks. Each network will have one coordinator since it is the network which has started it. It acts as a Trust center and repository for security keys since it stores information about the network.
(ii) **ZigBee Router (ZR):** Not only running an application, it can act as an intermediate router, passing data from one device to other devices.
(iii) **ZigBee End Device (ZED):** It will just talk to the parent node and it cannot relay data to toher devices. Because of this nature it will go asleep for longer period of time thereby increasing the lifetime of the battery. Amoung ZR, ZC and ZED, ZED require less memory and hence less expensive to manufacture.
Advantages of ZigBee: ZigBee provide the following advantages.
(1) Low power consumption. Since the data rate is small its power consumption is less.
(2) Long Life of the batteries of sensors from months to years.
(3) Depending on power requirements and latency it has different modes and states such as park, hold, active, etc.
(4) Energy saving by suing ZigBee devices. ZigBee saves megawatts of power and is more economical.
(5) It is low cost to design, implement and maintain.
(6) We can have high density of nodes in the network.
(7) ZigBee protocol is simple protocol and it is implemented globally. 2.4 GHz band is the widely used band for ZigBeee and is accepted almost in all the countries.

Table 1: Comparison between ZigBee, Wi-Fi and Bluetooth [16]

	ZigBee	Wi-Fi	Bluetooth
Range	10-100 meters	50-100 meters	10 – 100 meters
Networking Topology	Ad-hoc, peer to peer, star, or mesh	Point to hub	Ad-hoc, very small networks
Operating Frequency	868 MHz (Europe) 900-928 MHz (NA), 2.4 GHz (worldwide)	2.4 and 5 GHz	2.4 GHz
Complexity (Device and application impact)	Low	High	High
Power Consumption (Battery option and life)	Very low (low power is a design goal)	High	Medium
Security	128 AES plus application layer security		64 and 128 bit encryption
Typical Applications	Industrial control and monitoring, sensor networks, building automation, home control and automation, toys, games	Wireless LAN connectivity, broadband Internet access	Wireless connectivity between devices such as phones, PDA, laptops, headsets

III . PROPOSED SYSTEM FOR INDUSTRIAL AUTOMATION

The proposed system consists of different sensors such as temperature sensor, Smoke sensor and Gas Sensors. This sensors sense different data such as temperature, smoke and gas and pass it on to the microcontroller. The microcontroller internally has two analog to digital converters. The physical quantity of the sensor is converted into the digital signal by ADC.

It also consists of LCD Display, GPRS/GSM modem, Relay, Driver Circuit, DC Fan, Water Pump and Buzzer circuit.

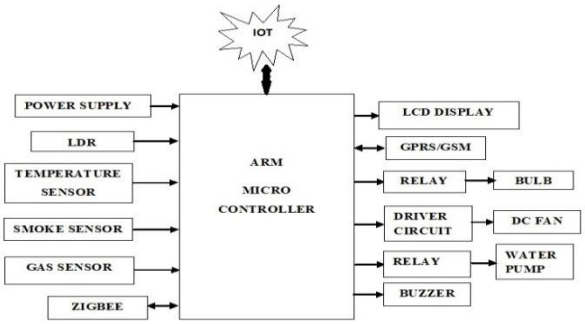

Figure 3: Proposed Block Diagram

IV. HOW THE SYSTEM WORKS

The Power supply supplies the power to the proposed system. LDR converts the light intensity into proportional electrical signal. If the light is more, signal is of more value and if the light intensity is less signal is of low value. According to the signal the bulb will be on or off. The temperature sensor senses the temperature and according to the temperature the DC Fan will be on or off. If the temperature is more Fan will be on and if the temperature is less Fan will be Off. If the smoke sensor senses the fire then the water pump will be on. Using the gas sensor the buzzer will be on if the gas is sense by the sensor.

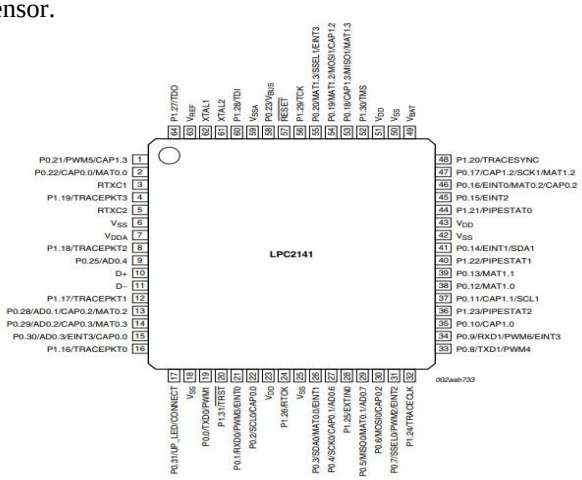

Figure 4 LPC2148 ARM Microcontroller [17]

LPC2148 ARM Microcontroller Pin configuration is shown above. It has total 64 pins. The function of each pin is shown in the diagram.

V RESULTS

The proposed system model is given below. It consists of all the sensors such as LDR, Temperature Sensor, Smoke sensor and Gas sensors. Also, it has GPRS model. Communication between the proposed system and the computer is through ZigBee Transmitter and Receiver. Because of ZigBee communication, less power is needed when compared to other IEEE communication protocols. Hence less power consumption takes place in this proposed system.

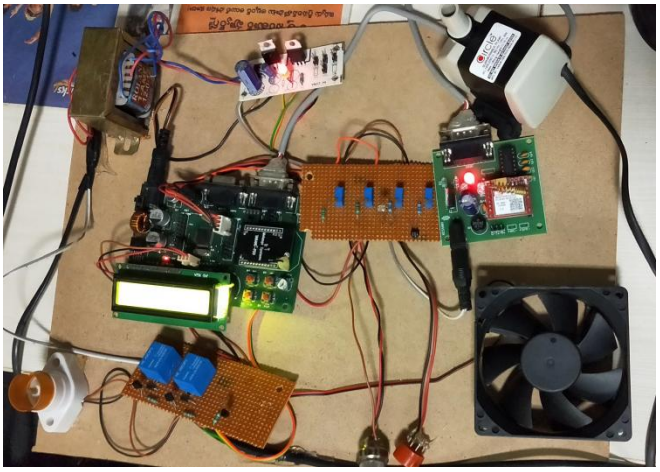

Figure 5 Proposed systems.

Through GPRS/GSM the system is connected to the internet.

Figure 6 GPRS Connection

Through GPRS the data such as LDR value, Temperature, Smoke and Gas values are sent to the internet. It will be displayed on the internet webpage as shown in the figure below.

Figure 7 Webpage showing different values.

Through IOT the different devices can be monitored from anywhere in the world using system login.

The ZigBee transmitter and Receiver are responsible for communication between computer and the proposed industrial automation system. It is shown in the below figure.

Figure 8 ZigBee Transmitter

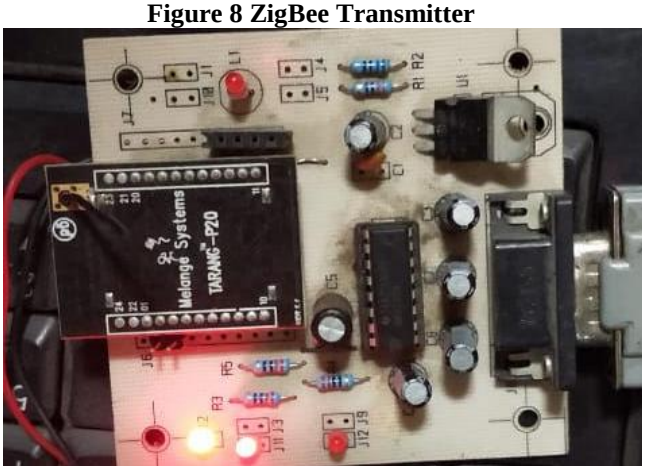

Figure 9 ZigBee Receiver

VI CONCLUSIONS

In embedded system Internet of Things is a new domain of the internet and it is becoming important topic for researchers. It find diverse application in the areas of both embedded and various communication architecture. Due to IoT Interconnectivity is possible between internet and the industrial devices. IoT provides thing-related services such as privacy protection and semantic consistency. IoT based system is heterogeneous as different hardware and networks are connected together. IoT responds to dynamic changes such as sleeping and waking up etc. It provides Enormous scaling of hardware and software. It also provides safety to the industrial automation system and human beings. Due to connectivity to different devices and the computer, it can monitor the health of any device of the industry. Hence IoT plays an important role in the coming future as it is accessible from anywhere in the world and the industry can be monitored from anywhere in the world. Also due to the use of ZigBee communication protocol less power consumption takes place between devices and the device lifetime increases tremendously.

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