278. Internet of Things (IoT) and Wireless Sensor Networks (WSNs) Based Smart Catastrophe Monitoring System for Factories

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Abstract

Disasters can be defined as a sudden, accidental event of great magnitude that causes considerable damage to life and property. In recent years accidents due to Catastrophic Failures in factories took thousands of lives and caused massive destruction of property. Nowadays Internet of things (IoT) is the emerging technology that has huge impact on society and day to day activities. With IoT sensors are embedded in our environment that collects information about the things and they share this information with each other to create a big picture about the environment. Integrating sensors are favorable in industries for the detection of unexpected incidents which can cause deaths. These sensors use their processing and communicating capabilities, sensing and monitoring power to detect such accidents. By utilizing such advanced technologies of IoT and Wireless Sensor Networks (WSNs) efficiently, catastrophic conditions and productivity of factories and industries can be improved. The self-organizing and self-configuring capabilities of WSNs make it more reliable and advantageous technology for the factories and industries. In our project, the WSNs and IoT are combined to lower the rate of catastrophic failures.

Keywords: *Catastrophic conditions; Internet of Things (IoT); Wireless Sensor Networks (WSNs); Reliability.*

1. Introduction:

Industrial accidents may lead to a great destruction, injury or deaths. Harrowing incident of Baldia Town factory Karachi Pakistan is an example of such situation, for some unknown reasons this Garment factory caught fire and the flames ignited the chemicals stored in the factory. The Baldia Town Factory inferno claimed the lives of 259 workers in the factory [1.]In 2012, the fire in garment and shoe factory in Karachi and Lahore respectfully is considered to be the most deadly in the history of Pakistan. It approximately killed 257 people and leaving behind more than 600 injured. Two great explosions occurred within 30 seconds at a container storage station at the port of Tianjin in the Binhai, China in August 12, 2015 [2] due to which 173 people died [3]. Disasters prove that an effective system can help to successfully manage a disaster relief operation potentially saving hundreds of lives [4]. If these accidents are not minimized by taking useful measures, they will continue to take human life and will be a great threat for humanity and property. Therefore in our project we present a reliable and easy to implement system for decreasing the life threatening results of these catastrophic failures by alarming the concerned authorities of any incident that has occurred, before it’s too late, so that they can take immediate actions after any industrial accident has occurred so as to minimize its deadly impacts. We use two advanced technologies; IoT and WSNs. WSNs can generally be described as a network of nodes that cooperatively sense and control the environment, enabling interaction between persons or computers and the surrounding environment. Many factories provide control and real-time support using sensors but they are too expensive and based on complex wired infrastructure [5].As WSNs provides intensified interest from industrial perspective due to the low powered and reasonable priced sensors therefore in order to overcome industrial disasters, it can be the preferable solution as compared to guided or wired systems as it provides the proficiency of implementation of sensor networks, displacement of complex, expensive and difficult deployment of wired systems, lower operating costs in the harsh factory environment, data redundancy, packet errors and so on. Due to the enhanced capabilities of WSNs, it can also be chosen for the efficient management services at the factories, energy efficient resources and security applications [6]. Internet of things (IoT) works parallel to WSNs hence, these tiny inexpensive and low powered sensors can be installed in any kind of environment at reasonable costs. Integration of these objects into IoT will be a major evolution of WSNs. This paper focuses on proposing an efficient detection system for catastrophic failures in factories and alarms the nearby places (emergency centre, residential area, school etc) so that the safety precautions can be made earlier. It also presents that the information is routed between the nodes on the basis of following factors:

- Minimum delay.
- Accurate signal delivery.
- Less interference.

These performance parameters of signals are evaluated by using wireshark network protocol analyzer which will capture packets and examine security problems.

Moreover, if one node fails then redundant node will be there to maintain the network**.**

A catastrophe management system is shown in fig. 1, where as soon as any accident due to catastrophic failure in factory is detected by wireless sensor network embedded in factory environment, the nearby places (i.e.; Residential Area, Schools etc.) will be notified of the accident via GSM and Android Application installed in user smart phones. Moreover the readings of the sensors are updated on a webpage Via IoT, so that the concerned authorities remain updated of the factory situation.

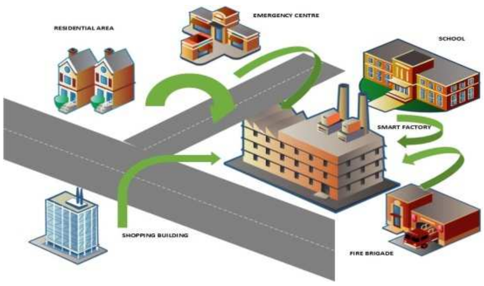

Fig. 1. Illustration of Information Dissemination Scenario.

The remainder of the paper is structured as follows. Section 2 will discuss related works and their drawbacks briefly. In Section 3, Project details, technical solutions and social impact on humanity or local community are discussed. Section 4 presents implementation steps which shows that how the intended task has been achieved. Experimental results that are achieved are discussed in section 5. Section 6 concludes the paper.

2. Project Details:

The catastrophe management system is composed of monitoring nodes containing different sensors, communications systems, and Internet access. The self-organized network of different sensors monitors the change in values including humidity, smoke, flame and temperature sensors etc. The sensors that are used are shown in Fig 2 and the details are given as follows:

A. **Temperature Sensor:** It detects temperature by evaluating the temperature of hot gases measuring fixed temperature or rate of-rise temperature thresholds.

B. **Humidity Sensor:** It detects the threshold levels of humidity in the atmospheric weather.

C. **Smoke Sensor:** It is often considered a reliable option for early warning fire detection. For that fire or smoke sensors are to be used to detect the fire by providing notification of a fire event to and/or fire departments.

D. **Flame Sensor:** Carbon Dioxide (CO_2) gases or flames are sensed by flammable sensors.

E. **Microcontroller (Arduino Mega):** based on the ATmega1280 processes data, performs its tasks and monitors the functionality with other components in the sensor node.

F. **WIFI-Module:** WIFI- Module (ESP8266) that allows microcontroller access to the Wifi network. It can be merged with the sensors as it possesses a high on-board processing and storage capability.

G. **Buzzer:** It is used to alarm the workers about any catastrophe situation. When such situation occurs, it will be alarmed to alert the people.

H. **B4A:** B4A is used in this project to develop the Android app. As smart phones are available to everyone so this app will be installed on them which will notify the public about the presence of factory catastrophic event.

2.1 Technical Solutions:

Three different ways will be used to send alerts in case of catastrophic failures:

- GSM Module in which through SMS the nearby people will be alerted.
- Android Application for smart phone.
- Webpage through which the data is sent on the cloud that highlights the database for catastrophic events in order to make a record.

2.2 Social Impact on Humanity or Local Community:

This project has made an attempt to lower the life threatening effects of factories disasters that affect both local population and may even cover a much larger area. We come forward with a reliable system to accomplish quick detection of catastrophes so that maximum remedies can be applied in a minimum range of time. The project provides ease and facilities to a lay man in an economic approach by alarming them of the catastrophic conditions. Nearby places are alerted and notified, so that useful measures can be taken at appropriate time to prevent loss of life and property. Information dissemination scenario is shown in above fig. 1 where information from a smart factory is sent to nearby places.

3. Implementation steps:

Transmitter node:

The transmitter node is composed of various sensors that sense the environmental readings. Various sensors that are smoke sensor, temperature sensor, flame sensor and humidity sensor are integrated into the ARDUINO microcontroller which after detecting any catastrophe sends the information not only to the employees working inside the factories but also to the nearby people (i.e.; Residential Area, Schools etc.) by using the alerting techniques.

Fig. 2. Block Diagram of transmitting node

The Flow Diagram of the transmitter node is shown below in Fig 4. Firstly, all the sensors and WIFI (8266) are initialized. Sensor readings are taken on the basis of comparing them with threshold value, if the sensor readings exceed the threshold value, the buzzer will be alarmed and the catastrophic condition will be detected and people will be alerted in the factory, that information will be disseminated to the nearby places (residential area, school, mosque etc.). They can acquire some safety measures earlier.

Fig. 3. Flow Diagram of transmitting node.

Receiver node: The receiver side of smart catastrophic management system composed of monitoring node (Arduino), Wi-Fi (IoT) and Buzzer module as described in figure (4):

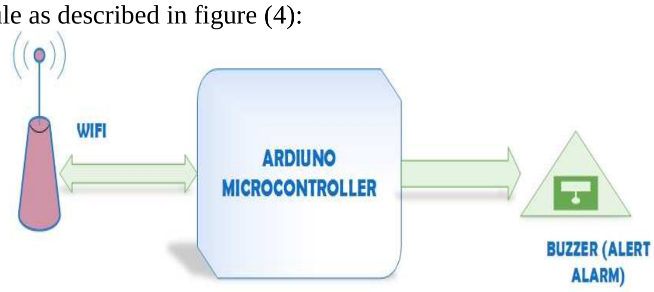

Fig. 4. Block Diagram of Receiver circuit.

The flow diagram of receiver side of smart catastrophic system to send the information to the web page is shown in figure (5):

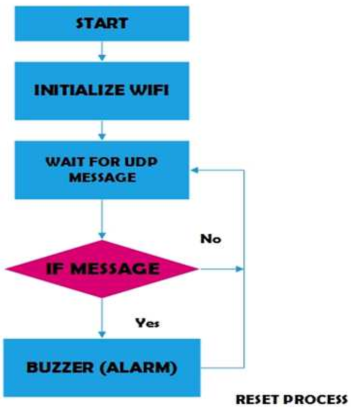

Fig. 5. Flow Diagram of Receiver circuit.

4. Experimental Results:

Transmitter side Implementation:

On transmitter side various sensors have been integrated and tested as shown in figure (6**):** The major advantage of these sensors are that they make a network of cost effective by reducing its complexity in a way that two sensors are merged in one sensor. DHT11 sensor provides the temperature and humidity levels at one time.

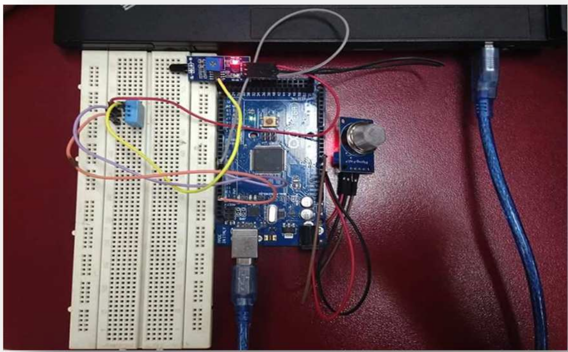

Fig. 6. Circuit of Transmitter Side.

Fig.7 shows the results when the sensors are tested and are interfaced with ARDUINO before any catastrophe/ fire have caught. It provides the notification of "no flame" as shown in fig. When no any catastrophe occurs.

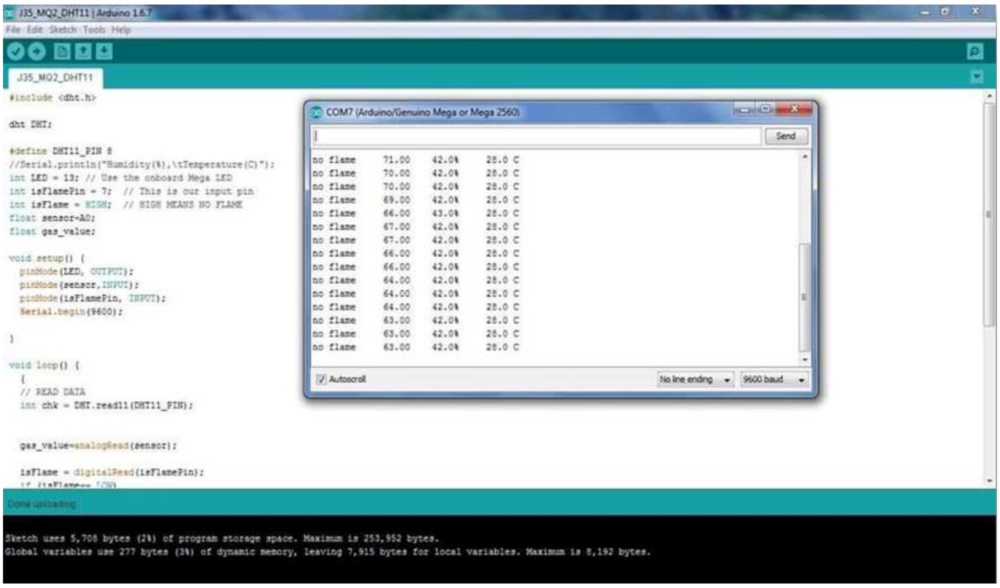

Fig. 7. Results before Flame.

Fig.8 shows the circuit diagram when any catastrophe/fire has been caught in the factory.

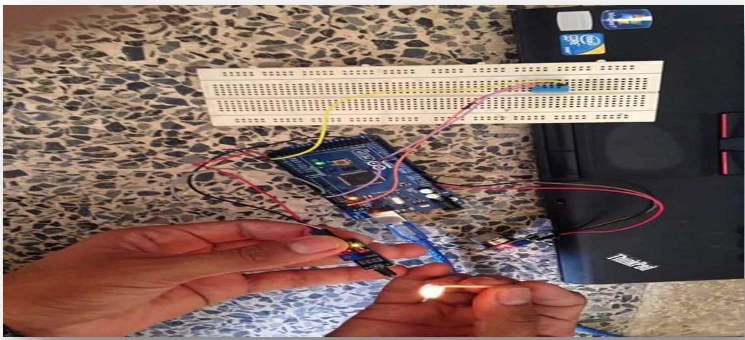

Fig. 8. Circuit Diagram of Flame

Fig.9 shows the results after any catastrophe or fire have occurred which provides the notification of “FLAME” to alert the workers.

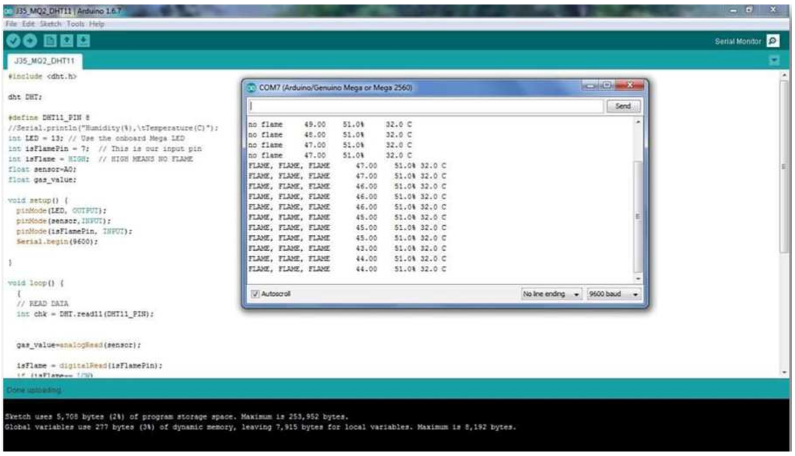

Fig. 9. Results after Flame

Fig.10 shows the circuit diagram at receiver side which shows the readings of factory environment at LCD.

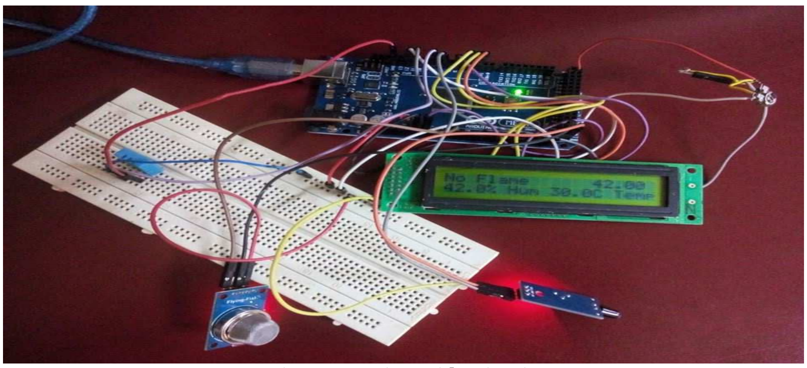

Fig. 10. Receiver Side Circuit

Fig.11 shows the data the graphs as well as the hardware circuit by which the data is sent on the webpage.

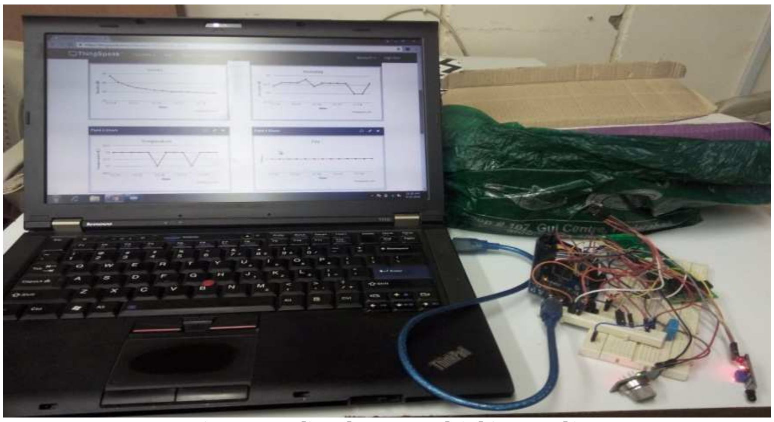

Fig. 11. Sending data on Web(ThingSpeak)

Fig. 12 shows the curves of each sensor readings in which the smoke, humidity and temperature readings are sensed according to the normal conditions of environment where as the fire reading value becomes 1 in the case of catastrophic occurrence. It becomes 0 in the absence of fire.

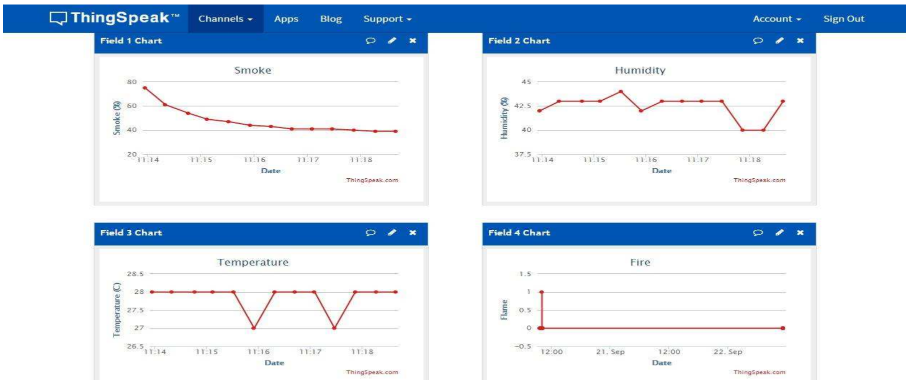

Fig. 12. Graphs of Sending data on Web(ThingSpeak)

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Appendix A

ARDUINO CODE

A.1. Temperature Sensor
A.2. Humidity Sensor
A.3. Flame Sensor
A.4. Smoke Sensor
A.5. GSM Module
A.6. Basic 4 Applications
A.7. Multiple Sensors
A.8. Aggregate Node