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Internet of Things based Earth Tremors Warning and Notification System using ESP8266 nodeMCU

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***Abstract* – A natural disaster is a phenomenon by which the living, as well as non-living things, belongs to the environment is suffering regularly. A human being does not have the power to totally eradicate the natural calamity but the only thing Human can do is, it can prior sense natural calamity & take major steps to minimize losses due to it. The main reason behind the development of earthquake alert system is the intimation of an earthquake in advance so that human losses can be minimized by evacuation of people to open places. There are many technologies available to predict and prevent the natural calamity. This paper is employing Internet of Things (IoT) technology for sensing earth-quake condition. Sensor node ESP8266 is preferred due to its cost-effectiveness, easy configuration for earthquake detection and sending the alert for the same. The sensor is equipped with an ESP8266 module for communication which directly connects to an internet. The Message Queuing Telemetry Transport (MQTT) protocol is used for message passing. The software used here is Arduino IDE where the three signals from each sensor corresponding X-Y-Z axis of the sensor is sensed and monitored in real-time.**

Keywords— Arduino IDE, Internet of Things (IoT), ESP8266 NodeMCU, Vibration sensor ADXL335, Message Queuing Telemetry Transport (MQTT).

I. INTRODUCTION

A Disaster is a natural or man-made hazard that causes serious severance in the Functioning of a community or a society. Disaster brings with it great damage, loss, destruction and devastation to not only human life and property but also to infra-structure, transport networks and economy. It is necessary to allocate the data and resources in a proper manner to reduce the impact of disaster, impact can certainly be minimized by creating proper methods of awareness of probable disaster to the concerned authorities. Internet of Things (IoT) can play a significant role in this channeling as well as transmission of data through efficient use of technology. The Earthquake is generally said to be a natural disaster which is also known as Earth tremor. The tremors is a sudden shake in the surface of the earth, which damages the buildings and kills hundreds of human and animal lives. Therefore by sensing the earth surface shock earlier by using sensors so as to warn public earlier. According to seismic wave's theory, Primary waves (P-waves) are compressional waves that are longitudinal in nature and the Secondary waves (S-waves) are shear waves that are transverse in nature. During an earthquake event, the P waves travel faster than S waves. Hence the public is warned earlier in few minutes or seconds prior by sensing the P waves. The sensor arrangement is spatially distributed to monitor the physical and environmental conditions for earthquake detection. The sensor assembly developed is low cost, have easy maintenance and it is robust. The sensor network is connection of several sensors that are connected to each other to perform the same functionality to monitor the environment condition.

The IoT is a computing concept which describes a future where every day and everywhere physical objects will be connected to the internet and can be able to identify themselves with other devices. IoT is the technique or network used in this paper for sending the accurate alert message to the public with accuracy. The IoT is a system of interrelated computing devices, mechanical and digital machines, ob-jects, animals or people that are provided with unique identifiers and has the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

The Wireless sensor network (WSN) is spatially placed sensors in an autonomous manner to monitor environmental parameters. IoT is the network of physical objects that enables these things to exchange, collect and connect data. Alphonsa A. and Ravi G. in Earth-quake Early Warning System by IOT using Wireless Sensor Net-works [1] proposed an earthquake early warning system by means of an IOT in WSN. The sensors are placed in the surface of the earth. Authers have used the ZigBee for communication purpose.

Design of Disaster Management System using IoT Based Interconnected Network with Smart City Monitoring [2] by Prabodh S. , Summeet H. and Savita have proposed a system of interconnected modules is developed so as to enable centralized data gathering as well as provide an

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interconnected network for data transmission in absence of existing infrastructure. Authors has given Emphasis on how an IoT sensing and communication technologies can effectively be used in smart city monitoring as well as in case of disaster management application. The hardware of the module used for this purpose is studied and explained in a detailed manner.

Proposed work on the landslides based upon the wireless sensor network. This paper focuses on the landslide detection by using system of 50sensors and 20 wireless sensor nodes, the system is deployed at Idukki, a district in the Kerala state, India. This paper explores algorithms for the power requirements and the sensor type and its properties along with the wireless sensor network architecture and the software modules. This paper has been implemented [3].

Table 1. Total number of people reported killed, by type of phenomenon and year (2007-2013)[4]

Natural Disaster	2007	2008	2009	2010	2011	2012	2013	Total
Draughts and Food Security	n.a	6	2	n.a.	n.a	n.a.	n.a.	8
Earthquake and Tsunamis	780	87918	1888	226735	20946	11	1120	339398
Extreme Temper-ature	1044	1608	1272	57064	806	1598	1982	65374
Floods	8565	4029	3534	8571	6142	3582	9819	44242
Forest Fires	150	86	190	135	10	22	35	628
Windstorms	6035	140985	3287	1498	3103	3102	9215	167225

In 2013, the number of people killed by natural disasters was their fourth lowest level of the decade and the deaths caused by technological disasters at third lowest. Over period of 2007-2013, among natural disasters, the number of deaths caused by earthquakes and tsunamis was highest following windstorms and Floods as indicated in table 1. The major disasters of the decade [4] were the Indian Ocean Tsunami in 2004(226408 deaths), Haiti earthquake in 2010(222570 deaths), deaths), the Sichuan earthquake in China 2008(87476 deaths), the 2005 Kashmir earthquake (74648 deaths).

II. SYSTEM DESIGN

The main aim of this paper is to detect the earth tremor and to alert the public earlier. It can be fulfilled by sending warning message with the help of IoT, as the IoT is the smart and accurate way of broadcasting the messages to the public. Thereby the smart phones, social media are warn with the alert message by IOT and thus the human are aware. The people having basic feature phones for those GSM module is used for alerting messages. Fig. 1 shows system block diagram

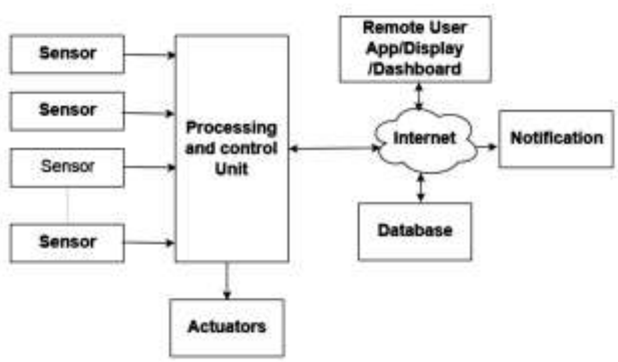

Figure 1: System Block Diagram

The following components used for designing,

1. Vibration sensors (Accelerometer ADXL335)
2. Arduino UNO Board
3. ESP8266 NodeMCU
4. LCD Module
5. USB Cable

The vibration sensors or Acceleration sensors are designed to measure the acceleration quantity. In this paper the accelerometer is used for detecting the earth vibrations and shakes. During earthquake event because of seismic action the P waves and S waves are generated. Out of P wave and S wave the P wave arrives first as the P waves propagates faster and has minimum impact to the surface whereas the S waves are the strongest wave and causes more impact to the surface of the earth and cause more damages the figure 2 shows simulation result of P-waves and S-Waves pattern and their time vs distance graph. The S-wave and P-wave also known as shear and compression waves. Thus the vibration sensors senses the P waves first so that humans can get the time for evacuation. The time interval between P waves and S waves varies as per the distance from the epicenter. Thus vibration sensor does its work by detecting the ground shocks and sending the signal to the Arduino microcontroller further which the message is sent to public by means of IoT or GSM technology. The

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ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The ADXL335 measures acceleration with a minimum full-scale range of +/-3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration that results from motion, shock, or vibration. The Accelerometer sensors are mounted inside the concrete slab and placed in stable area for sensing the vibrations.[6]Arduino is platform used for building electronics projects and also it is open-source. Arduino consists of both a physical programmable circuit board (microcontroller) and a piece of software called IDE (Integrated Development Environment) that runs on computer machine, used to flash computer code to the actual board. As soon as the shockwave hits the sensor the Arduino sends alert message. The thresh-old value for the sensor is fixed at certain level, beyond which the alert needs to be sent. Initially when the system turns on the microcontroller reads the sensor values for calibration purpose, once the calibration phase gets over the microcontroller enters into monitoring mode where it continuously monitors the seismic activity. The ESP8266 Wi-Fi NodeMCU Module is a SOC with integrated TCP/IP proto-col stack that gives any kind of microcontroller access to Wi-Fi network. The ESP8266 module is an extremely cost effective board with a huge, and ever growing support community forum. Here in this paper the Arduino gives the real-time data to the ESP8266 Wi-Fi board which uploads it to the dedicated webpage or application so that data logging and monitoring. Thus the ESP8266 gives the complete internet connectivity by means of Wi-Fi technology so that the remote sensor site can be accessible from anywhere in the world so public gets notification as soon as the seismic activity occurs. The Message Queuing Telemetry Transport (MQTT) protocol is used for message passing. MQTT is a transport protocol which uses net-work bandwidth efficiently with a 2 byte fixed header [9]. MQTT works on TCP and gives delivery assurance of messages from node to the server .Ideally MQTT is suited for the IoT nodes which have limited capabilities and resources.

III. SIMULATED RESULT

The System is first tested using the Arduino serial monitor. The results are as Shown in figure 3 and figure 4.The figure 3 shows plots of signal acquired from sensors. The figure 4 shows the real-time data acquired from the accelerometer sensor. This data is sent to internet using the ESP8266 NodeMCU. The data acquired is rest position data. sensor calibration is done and threshold value is adjusted be-yond which the alert needs to be sent. The figure shows the sensor value corresponding to X-Y-Z directions. Here only one sensor reading is shown in actual practice there will be multiple sensors deployed for monitoring purpose.

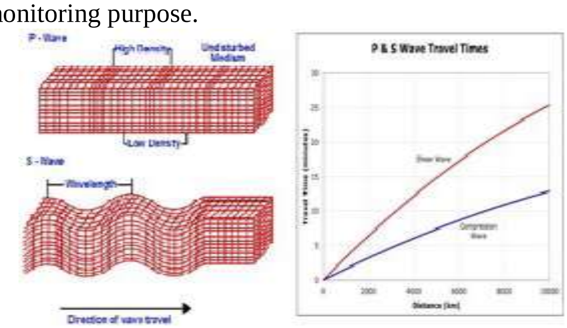

Figure 2: P-wave and S-wave travel pattern and Time Vs Distance Graph

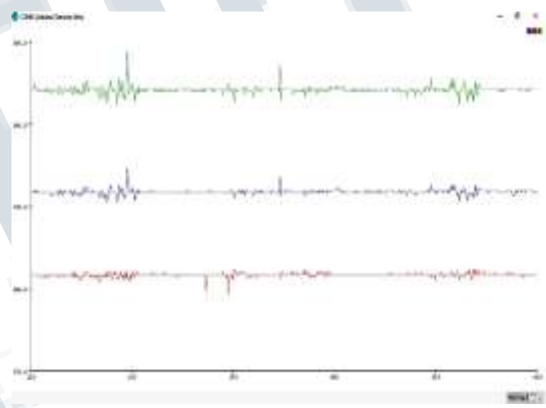

Figure 3: Output waveforms simulated using Arduino IDE

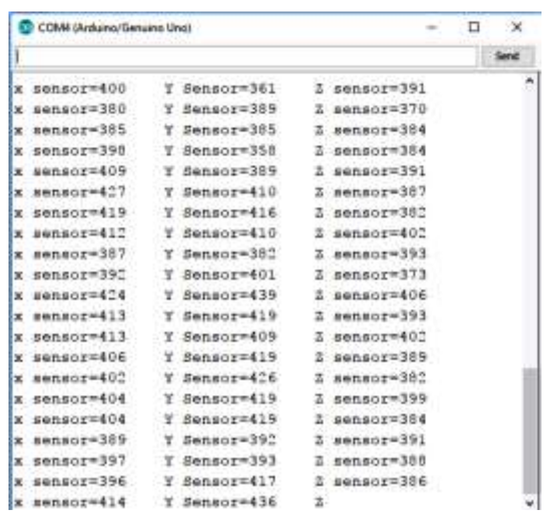

Figure 4: Real-time sensor data

CONCLUSION

This paper focuses an IoT based earthquake notification system, using Arduino and ESP8266 board. The sensor part along with Microcontroller comes under hard-ware part which detects the signals. The software part consist of code which takes decision for sending notification for evacuation purpose. Each sensor is connected to internet by using Wi-Fi technology. The Arduino IDE is used for sensor values monitoring and logging by numerical and graphical representation. The GSM technology is used for messaging to feature phone owners. Earthquake notification sys-tem efficient in terms of time response, complexity, power consumption, cost respectively. The ESP8266 nodeMCU is extremely useful in terms network connectivity, easy configuration,size. Circuit is designed, implemented and simu-lated using Arduino IDE tool.

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