Coal Mine Monitoring System for Rescue and Protection using ZigBee

Shilpa Lande1, Prof.Matte P.N2,
1PG student, E&TC Department, G. H. Raisoni College of Engineering, Chas, Ahmednagar, India
2Professor, E&TC Department, G. H. Raisoni College of Engineering Pune, India

***Abstract*—Motivation for better development of communication infrastructure comes form coal mine accident. At the time of emergency accurate information of the environmental condition should provide with great ease to the rescue team & this can be achieved by proper communication. This paper discusses continuous monitoring of underground coal mine parameter like gases, temperature, humidity & vibration. The various parameter information is sense, collected and stored in microcontroller (ARM 7) using respective sensor. All this information send towards monitoring section. In the monitoring section there is one GUI created. Decision is taken accordingly through which mine worker are informed through buzzer One of the applications of WSN that is Zigbee protocol, IEEE 802.15.4 standard is used for communication. The communication between hardware circuit in coal mine and administrator done through the Zigbee. This system is adaptive & highly beneficial for rescue & protection.**

***Index Terms*—** Wireless sensor Network, Zigbee, LPC2148.

I. INTRODUCTION

In the last few years for almost every country the environmental care has become one of the biggest aspects. In the last decades, the industrial accidents level has been increasing without any control in the last decades. So there is more hazardous environment of current situation in any industry. For monitoring and control of environmental parameters of the hazardous area, the modern industry is demanding for instrumentation. So the people safety and losses of property are important to maintain equilibrium between them.

The disasters of a coal mine happening are due to the complexity of mine environment and variety of the work condition of coal mine , so it is very necessary to monitor mine working environment. The various environmental parameters of mine safety monitoring and controlling system, such as methane, carbon monoxide, temperature, oxygen and so on, are currently using traditional cable transmission. Thus truly mine methane; carbon monoxide gas accumulation area mechanized mining face, such as dead gob cable security parameters cannot be monitored so they cannot predict the alarm. A variety of products for the current diversity of the coal mine safety and underground coal mine process variability space, mine safety wireless network should be compatible with the existing mine safety system with the data transmission functions has good flexibility, scalability, self set of network capabilities. As the mine has its own special applications require a simple sensor network protocols, network easy, self organization, self healing ability.

II. REVIEW OF LITERATURE

In any hazardous work environment mines safety of human life is an important concern. Mines and specially coal mines are places where constantly lives are lost and many countless are injured due to landsides and explosions.

Technological innovation such as use of higher utilization and distribution voltages and associated switchgear, the use of programmable logic controllers (PLC's) for control, monitoring, and diagnostic applications, improved protective relaying with built-in test circuitry, power-factor correction near loads for improved voltage regulation, and modifications to power-system component arrangement[1]. This paper shows an experimental RF propagation in two underground coal mines at frequency of 900 MHz [2]. An agent-based wireless local positioning system with ZigBee technology is proposed in this paper[3]. This paper mainly describes the basic nodes location principle and algorithm of WSN, proposes the location algorithm which is suitable for coal mine environment, and improves it based on traditional ranging and location method by combining Ultra wideband Technology and WSN [4].

In this paper, a positioning system of non-complete coverage of the whole tunnel network by measuring point is proposed[5]. A Emergency Communication System based on Wireless Mesh Network (ECS-WMN) is proposed, which is easy to deploy and report the incidents and information such as personnel positions to the field rescue center and related members of rescue groups using different approaches[6]

Underground mines are interconnected networks of cross cuts, uneven structure, tunnels, substation, shafts, escape routes and rail tracks [7]. Different types of support system are present either in the form of wood, metal & bolted reinforcement [8].

1. Uneven Structure

The underground mines do not have smooth surface through the mine. The hang wall and foot wall from mine to mine have discontinuous in the thickness. This leads to the poor signal strength at the receiver end because of scattering and reflection phenomena inside the underground mines[7].

2. Poor Line of Sight

A direct LOS provides an efficient communication process because the transmitter can direct ends signals to the receiver which results in enhanced signal strength at the receiver which results in enhanced signal strength at the receiver. Attenuation & propagation delays affect the overall communication where there is no LOS path between the transmitter & receiver. Moving vehicles, equipment, mine personnel blockage are also some time cause of no direct LOS for transmission [7].

3. Noise

Noise due to operation of mining equipment inside the underground mine degrades the signal quality; transmitted by a transmitter. This may affect the performance of a communication system seriously. Noise in signal added either externally or internally reduces the range of communication system [7]. Although in case of rescue operation this is somewhat reduced due to power failures but electronic devices and other mechanical rescue equipment carried by the rescue team may add noise to the transmitted signal [7].

4. Tunnel as a waveguide

It has been observed that an underground mine tunnel behaves as waveguide at certain frequencies thus transmitted signal has enhanced coverage range [9].

5.Gaseous environment

Different gases are present inside the mine tunnels. The main oncern in underground mines are methane which is highly flammable. Other toxic gases are also there which may also cause degradation of signal quality [7].

6.Warm conditions and humidity

A mining environment also has relative humidity up to 90% [1]. Usually as we go deeper the temperature rises. this high humidity affect the signal propagation for communication should be intrinsically safe for normal operations and activities as per the mining regulations [7].

Mining Method

The different methods adopted for efficient production of coal have been reviewed in [10]. The methods include long wall mining, board and piller mining, using draglines, using track and shovels, continuous high wall mining , auger mining.

Underground Mine Communication

Underground mine communication techniques can be broadly classified into mainly three categories [8] : Through The Earth[TTE], Through The Wire[TTW], Through The Air[TTA]. Apart from these, other techniques are also used for communication and safety purpose which include carrier current system and hybrid system[8].

1] Through The Earth [TTE]

Through The Earth communication techniques has been widely researched for communication purpose as well for rescue operation in emergency. Very low frequencies are used to increase the range because the attenuation in electromagnetic signal decreases with frequency [8]. It involves very large transmitting antenna managed on the surface of mine. Through the earth communication techniques are used by following communication systems : Personnel emergency Device[PED], TeleMAg Tam Guard Miner Track& subterranean wireless electrical communication system. Communication is limited to text messages because data rate is very low operating on these frequencies [8].

2] Through The Wire[TTW]

Through the wire communication technique provides log distance communication in a routing operation of the mine due to fixed infrastructure [3]. It works well in normal mining operation but is highly vulnerable to damage and lead to entire system breakdown in accidents involving roof walls fire and mine collapse and s on different kinds of electrical conductors are used for signal transmission (for eg twisted co-axial cable and optical fiber). Some of communication devices used in mines is sound powered phone, magneto type phone, bell signaling paging phones, dial and page phone.

3] Through The Air [TTA]

TTA communication technology has drawn a significant attention of researchers and different manufacturers across the globe due to need of infrastructure, less communication systems and reliability in emergency scenarios. These techniques use a wireless link for signal transmission. Underground mine environment either in coal mine or metal mines creates a very big challenge for wireless communication. Wireless networks Wi-Fi, walki- talkie, UWB communications are classified into through the air categories [8]. TTW communication systems have certain limitation. Hence it forces the mining industry to have option for TTA communication technology which is more reliable, easy to maintain and economic in comparison to TTW communication system.

Existing system

At present, the coal mine gas monitoring system is generally composed of the monitoring sensor, underground section[11], information transmission system and surface centre. The junction between the underground substations with the surface centre compose of the information

transmission system directly effect on the transmission quality of information and investment cost of the system. The information transmission system can be divided into 3 kinds according to their structure: radial, circular, tree[6]. The tree system is widely used by most of the coal mines at present, at the same time one substation is joined with several monitoring signals so as to reduce the system branches and all the substations undermine join the system cable nearby which comes from the surface centre with underground substations at the condition of equal monitoring capacity.

Disadvantages of Existing System

Due to the wired system the arrangement of system become complex. When any fire accidents occur we have a chance of breakage in fibers. We don't have continuity in getting the information in such cases. We will not have direct contact to the base station. Inside mines due to uncomfortable situation the installation cost as well as maintenance cost is high for wired communication.

Now we are proposed an advanced wireless system for coal mines to update the underground situation in coal mines to ground station immediately by sending the information on the coal mine application running on the coal mine application running on the android phone of authorized person.

III. SYSTEM OVERVIEW

After the comparative study of past and existing system in coal mines we proposed a safety monitoring system. This safety system is divided into 2 parts

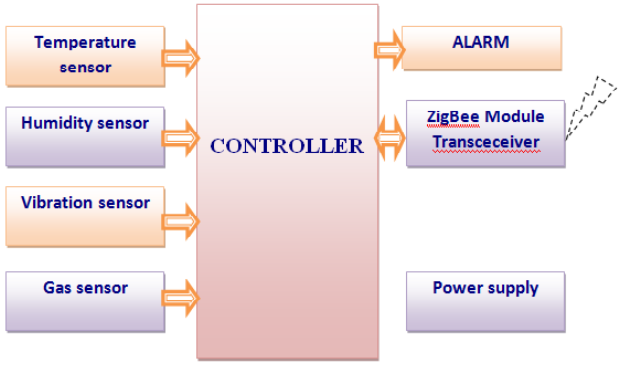


Fig 1 Mining Section

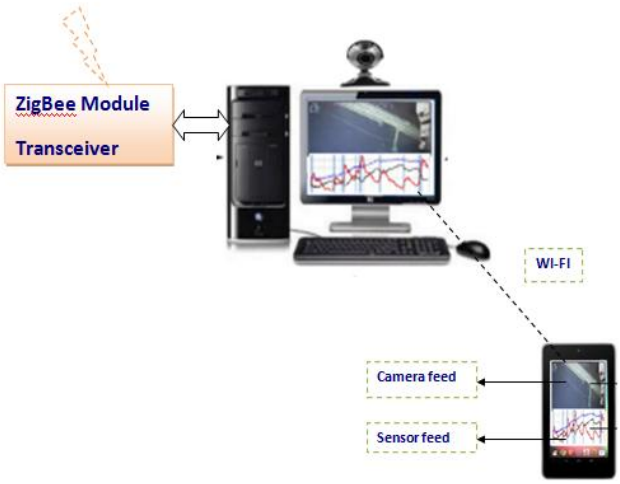


Fig 2 Monitoring Section

IV. DESIGN OF HARDWARE

Mining Section

1. Controller

LPC 2148 controller of ARM 7 family is controller and processing unit which is one of the important part of project. It is the whole control of the project. It controls the entire associated device with it. The input/output ports of this controller are used for this

It does various functions as:

1.It receives the analog value form the sensor

2.Convert that analog value into the digital values.

3.Compare that value with the threshold level set by administrator.

4. According to result of comparison it gives the current to device driver.

2.ZigBee

ZigBee is used for low cost, low data rate, long battery life. In zigbee application total time required to perform in activity is low. Zigbee spend its time in power saving operation. Zigbee is capable to operate for many years without replacing its battery. Zigbee is designed especially for low cost implementation of low data rate application. Here Zigbee is used for communication purpose.

3.Temperature sensor

A thermistor is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. The word is a combination of thermal and resistor. Thermistors are widely used in current limiters, temperature sensors, self-resetting overcurrent protectors, and self-regulating heating elements

4.Humidity sensor

This sensor module converts relative humidity(30-90%RH) to voltage and can be used in weather monitoring application**.**

5.Vibration sensor

If any vibrations detected inside the coal mine then the output of vibration sensor i.e. analog output goes to the controller. It has TTL level signal output. Output valid signal is high the LED goes out. It has Adjustable sensitivity (fine tuning) vibration detection range is wide.

6.Gas sensor

This is a simple-to-use LPG sensor, suitable for sensing LPG (composed of mostly propane and butane) concentrations in the air. The MQ-6 can detect gas concentrations anywhere from 200 to 10000ppm. This sensor has a high sensitivity and fast response time. The sensor's output is a analog resistance. The drive circuit is very simple.

7.Alarm

Buzzer will be turned on when the sensor output crosses the threshold level detected by sensor. Here piezoelectric sensor is used.

Monitoring section

At the monitoring section we used the server and android phone for monitoring. The server is operated by the administrator. If the administrator is not available at the monitoring node then that data is also send on the android phone using internet connection.

VI. WORKING OF THE SYSTEM

1. Mining Section-

In the Mining section, the parameters like temperature, humidity, Gas are measure by means of respective sensor and the output voltage measured by them is directly connected to the ADC of the ARM as the output voltage never exceeds 5V, there is no need of the signal conditioning circuit. The number of people inside the coal mine is monitored. During the hazard this information will be useful. Information regarding the safety measures like wearing oxygen helmet etc. will be already given to the workers so that they can save their life. If any of the received parameters are beyond the ultra limit, then a Buzzer will be ON, giving warning o the people. The parameters are transmitted to the ground section through a zigbee transceiver.

2. Monitoring Section

In the monitoring section Zigbee transceiver receives the information and sends to the administrator. The monitor connected to the administrator displays information in the ground section. This administrator is also connected to the admin's android phone through Wi-Fi network for continuous monitoring. Also the camera connected to the administrator continuously scans the surrounding and send it on the admin android application for precaution purpose.

In the Ground Section on the Server PC there is Neat bean platform. When we run a project Login frame is open so we have to fill password when password matches then we have to go to welcome form otherwise we have to cancel from it. Then on the welcome frame there is com port selection. When we entered proper com port then main form is open. On this main form frame 4 options are available as follows

1. Test Device

2. Test Sensor

3. Test Webcam

4. Control/ Monitor of Administrator

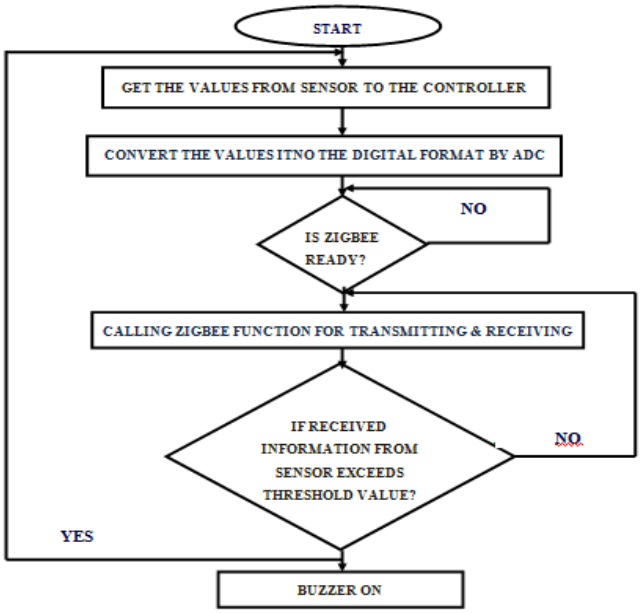
When we choose test Device option then there is control of on/ off the device. When we choose the Test Sensor options then senor output is available on screen with the progress bar. When we press Test webcam option then the camera feed is available which scans the surrounding of server. When we press the fourth option that is control/ monitor of administrator then there is all control and monitoring options are available.

When administrator is not available at the server or it is away from the server then for continuous monitoring, Android application is created which is running on the android phone. When administrator opens that application then first he should enter IP address of PC that is Server's IP address. When this both address matches then second welcome frame is open which wants the password of application. So administrator must enter that password. When the password matches then second frame opens. On that there are two options 1.Check connection 2. Control/ Monitor Devices and Sensor

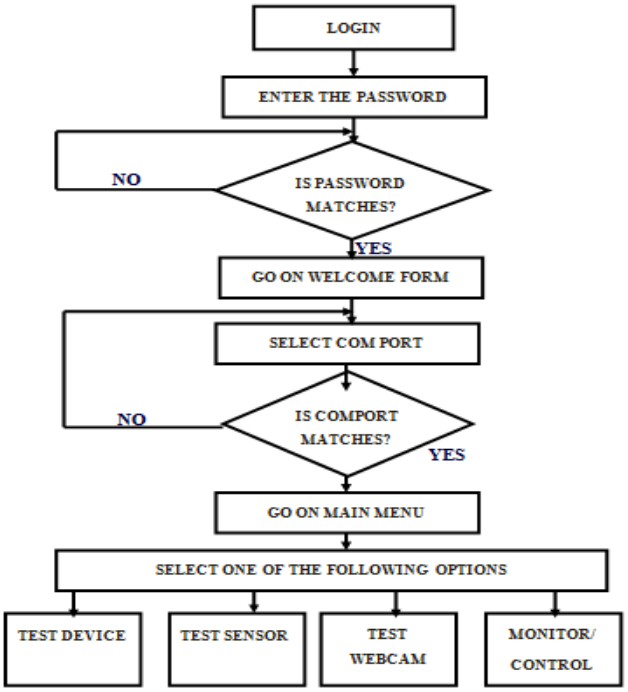
V.DESIGN FLOW

Flow chart for the mining section is shown

following Fig.



Flowchart 1 for Mining Section



Flowchart 3Flow chart for GUI running on Server

Flow chart for Monitoring Section is shown in the Flowchart 2. This flow chart shows the communication action between Monitoring Section and Mining Section.

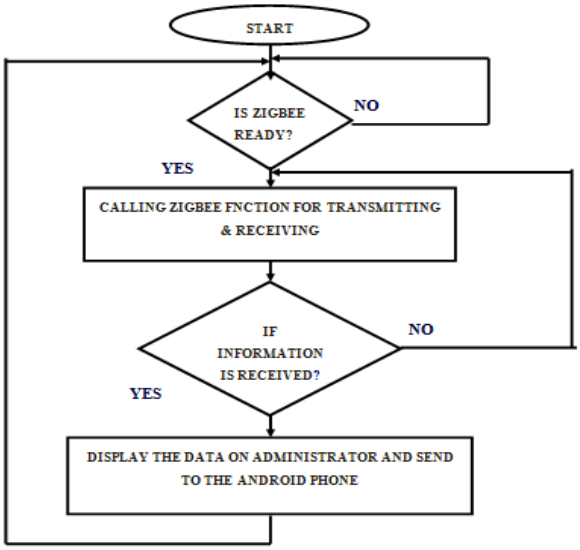


Fig 4 . Flow-chart for Monitoring Section.

V. RESULT & CONCLUSION

Results

A. Result in normal condition

Table 1. Result in normal condition

Sr No	Name of Sensor	Threshold value Set By Admin	Actual Value	Hardware changes	Remark
1	Temperature sensor	20	19	Buzzer off	In safe condition
2	Gas Sensor	40	35	Buzzer off	In safe condition
3	Humidity Sensor	45	43	Buzzer off	In safe condition
4	Vibration Sensor	127	00	Buzzer off	In safe condition

The above table shows the result in normal condition.

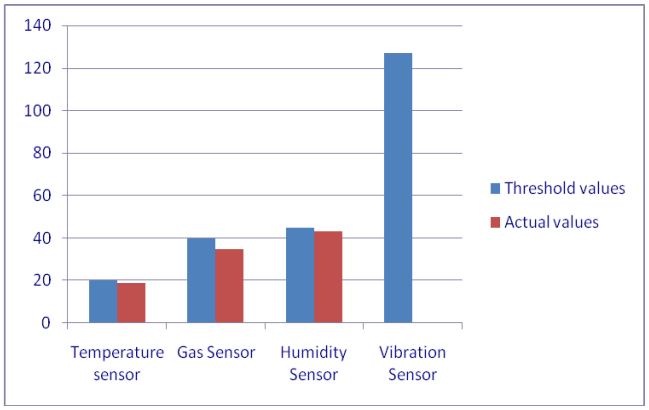


Chart 1 Result in Normal conditions

B.Result in abnormal condition

Table 2 Result in abnormal condition

Sr No	Name of Sensor	Threshold value Set By Admin	Actual Value	Hardware changes	Remark
1	Temperature sensor	20	21	Buzzer on	In Dangerous condition
2	Gas Sensor	40	44	Buzzer on	In Dangerous condition
3	Humidity Sensor	45	71	Buzzer on	In Dangerous condition
4	Vibration Sensor	127	00	Buzzer off	In safe condition

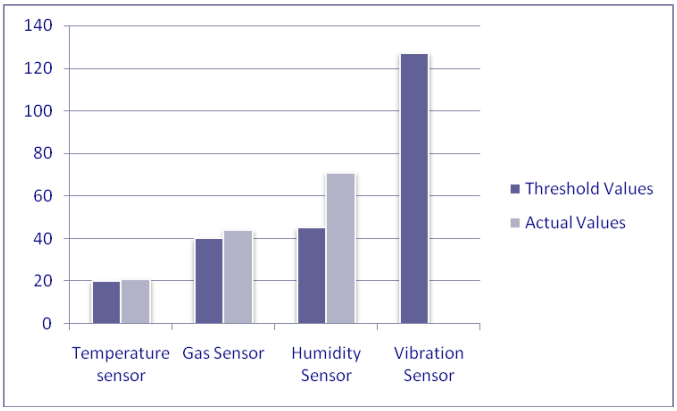


Chart 2. Rsult in abnormal condition

The above two table shows the result in normal and in abnormal conditions. In abnormal condition the buzzer is on and it is helpful to take a proper decision for workers. All this information is continuously send to the monitoring section for the administrator hence one GUI is created on the Server.

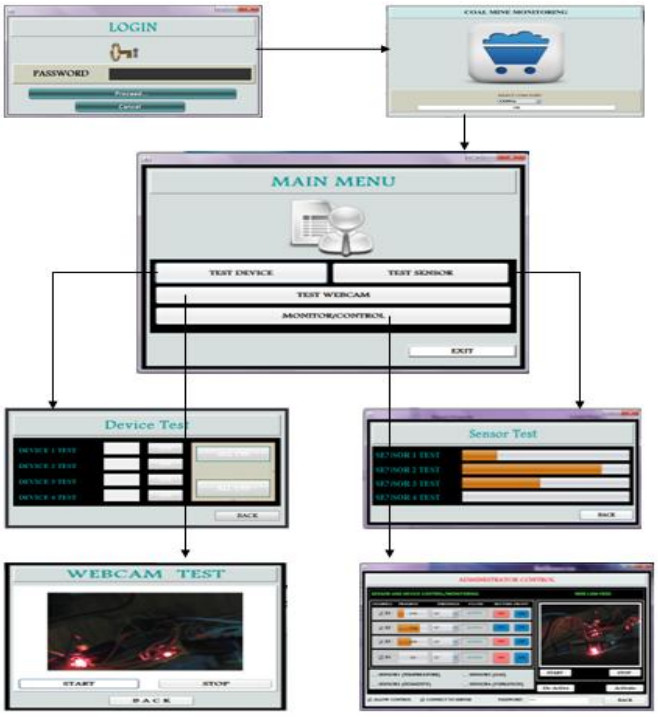


Fig 5 Graphical User Interface created on administrator for monitoring

Conclusion

The use of wired system in the restricated enviromnetal mine parameter monitoring is limited to provide the safety assurance and communication capabilities. WSN gives an alternative for portable wirelesss communication by using ZigBee network. ZigBee neetwork gives network connectivity in a low cost, low power consumption and long battery life. Thefore large area inside the hazardous coal mines are covered and accidents are controlled effectively by taking proper decision

REFRENCES

[1] Thomas Novak, Jeffery L. Kohler "Technological Innovations in Deep Coal Mine Power Systems", IEEE Transactions on Industry Applications, Vol. 34, No. 1, pp-196-204 January/February 1998

[2] Y.P Zhang, G.X Zheng, J.H Sheng, "Radio prapogation at 900 Mhz in underground col mines", IEEE transaction on antenna Prapogation, Vol.49(5)PP 752-62, 2001

[3] H.K Chan, " Agent Based Factory Level Wireless Local Positioning System With Zigbee Tchnology", IEEE System Jounal, vol.4(2), PP 170-85,2010.

[4] Wu Chunming, "The Research of Coal Mine Location Technology Based on the Ultra-Wideband Wireless Sensor Networks ", International Conference on Intelligent Computation Technology and Automation, IEEE Computer society pp-897-900., 2010

[5] Zhigao Liu and Chunwen Li , Qingqing Ding and Danchen Wu "A coal mine personnel global positioning system based on wireless sensor networks" Proceedings of the 8th World Congress on Intelligent Control and Automation, IEEE July 6-9 2010, Jinan, China.

[6] SONG Wen, WANG Fei, DAI Jianbo "A Emergency Communication System Based on WMN in Underground Mine" International Conference on Computer Application and System Modeling (ICCASM 2010).

[7] Misara, P.Kanhere, Salil, ostry, Diethelm. Jha, Sanjay: safety assurance and Rescue communication system in high stress Environments: A Mining Case Study, Topics Design & Implementation, IEEE communication Magzine, pp.66-73,(2010)

[8]Bandyopadhay, L.K., Chaulya, S.K. and Mishra,P.K., wireless communication in Underground mines, RFID Based Sensor Networking, Springer Pblications, New York(2010)

[9] Kennedy, G., Bedford, M., Foster, P., Jones, B.: Underground Tracking and Positioning Techniques Using Wireless Mesh Networking Technology, 34th International Conference of Safety in Mines Research Institutes, pp.611-624, Macmillan Publishers, (2011).

[10]C. Ozgen Karacan Felicia A. Ruiz Michael Caste Sally Phipps "Coal Mine Methane: A review of capture and utilization practices with benefits to mining safety and to greenhouse gas reduction" International Journal of Coal Geology 86(2011) 121-156 ISSN: 0166-5162

[11]Y.P Zhang, G.X Zheng, J.H Sheng, "Radio prapogation at 900 Mhz in underground col mines", IEEE transaction on antenna Prapogation, Vol.49(5)PP 752-62, 2001.

