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A Safe Guard System For Mine Workers Using Wireless Sensor Networks

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ABSTRACT

Industrial Safety is one of the main aspects of industry specially mining industry. In the mining industry safety is a very vital factor. To avoid loss of material and damaging of human health, Protection System as well as faithful communication system is necessary inside the underground mines.
To increase both safety and productivity in mines, a reliable communication must be established between workers, moving in the mine, and a fixed base station. Inside mines, the wired communication system is not so effective. In this paper we are going to monitor the mine parameters like abnormal gas, temperature, water and humidity to avoid the harmful gas or high temperature attacking the mine workers using wireless sensor network with less power utilization and Direct Diffusion routing techniques. Inside underground mines, the wired communication network system is not so effective. For the successfull wireless data transmission, in this work the ZigBee specification is utilized.

Key words - Wireless, Mine, Reliable, Temperature sensor, Humidity sensor, Gas sensor, low power utilization and Zigbee.

I. INTRODUCTION

Safety is the most vital part of any type of industry. Negligence in the safety part may cause damaging of high quality equipment hampering of production or may cause loss of human life also in extreme cases. In the mining industry safety and security is a fundamental aspect of all. To avoid any types of unwanted phenomena all mining industry follows some basic precaution and phenomena. Communication is the most vital key factor today, to monitor different parameters continuously and to take necessary actions accordingly to avoid any types of hazards related to production, security, managing of human resources. To avoid loss of material and damaging of human health, security and safety system as well as reliable continuous faithful communication system is essential in the interior of the underground mines. To enhance security, safety and productivity in underground mines, a reliable communication system must be established between workers, moving in the mine, and a fixed base station. The communication network must not be interrupted at any moment and at any condition.

Inside underground mines, the wired communication network system is not so effective. The reliability and long life of conventional communications systems in harsh mining environments has always been a problem. Inside mines due to uncomfortable situation the installation cost as well as maintenance cost is high for wired communication networks. It is very difficult to reinstall the wired communication system inside mines after a landslide or damage due to any reason. If due to some reason any wire of the communication network damages, it may cause temporary interruption of the continuous process or may cause a long term break down of the system.

Due to roof slide, if by any means some workers trapped inside mines, it is very much required to maintain the continuity of the communication system. It is very much important to know the actual position and condition of the trapped workers. To monitor other parameters during this condition it is very much necessary to maintain the communication system as usual. Accordingly, development of mine monitoring system to accurately detect temperature, to track underground miners and vehicles on real-time has significant meaning to safety production and rescue of underground mine disaster.

Coal mine safety monitoring system based on wireless sensor network can timely and accurately reflect dynamic situation of staff in the underground regions to ground computer system. In Existing System, In traditional method the abnormal in any one of the parameters are transmitted in wireless communication to intimate the status to monitoring section and in this method no alert in the form of voice is given to the workers inside the mine. Hence we go for proposed system.

For the successfully wireless data transmission, in this work the ZigBee specification is utilized. In this system, the basic parameters like temperature, humidity, water and hazardous methane gas are going to be monitored and if any abnormality happen in any of the parameters means it will be intimated in the form of voice within the mine and transmitted to the monitoring section via zigbee. For that we are having system with Microcontroller, in that the sensors are interfaced with it. Here a voice IC named APR9600 is used for intimating the abnormal status in voice format.

The paper is organized in the following sequence. A small literature survey about problems occurred in existing system was given in the previous paragraphs. Section 2 describes the development of the block diagram and its components for the safety system for mine workers. Section 3 describes Mine Section technology that is components and its description. Section 4 describes about Monitoring Section and its component description. Section 5 describes low power utilization in WSN Section 6 describes about Safety system for mine workers and working of it. Section 7 is content with conclusion. This is followed by the references.

II. DESIGN OF THE EMBEDDED SYSTEM BLOCKS

The block diagram of the design is shown in the Fig. 1(Mine section) & has a Microcontroller, LCD, Temperature sensor, Gas sensor, Humidity sensor, Voice play back circuit, ZigBee, and Power interact with each other as follows: When switched on, the power supply supplies 5V to microcontroller for its operation. When the Digital signal board is on, a signal is transmitted by ZigBee.

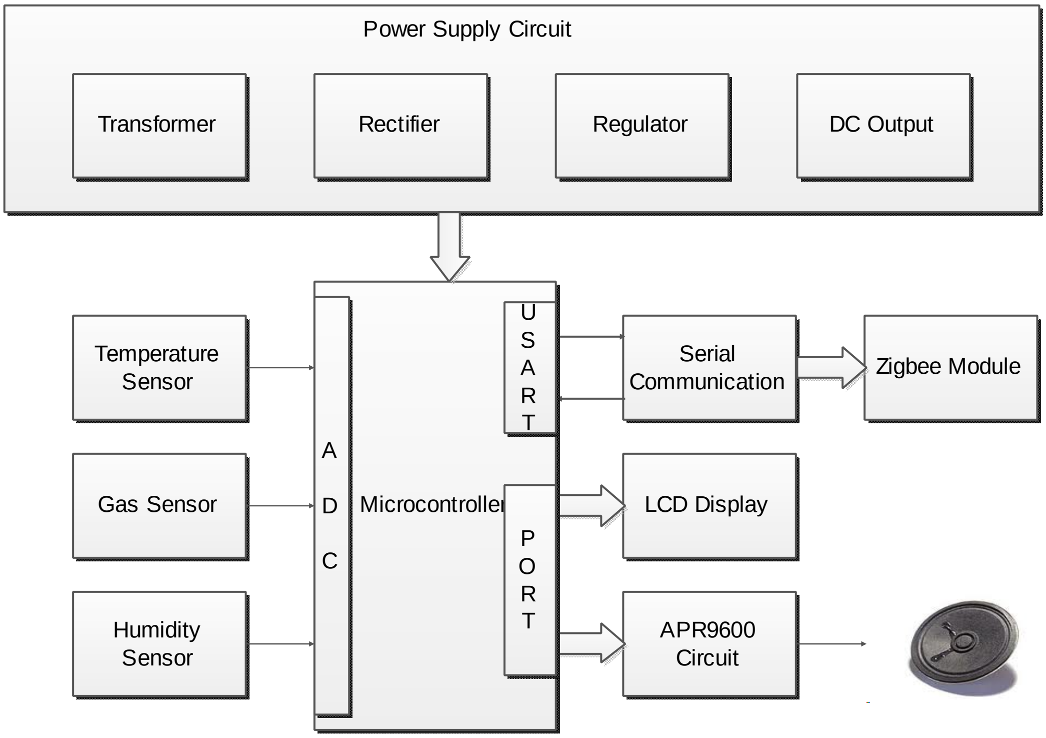

Fig 1: Mine Section

The block diagram of the design is shown in the Fig. 2(Monitoring section) & has a ZigBee, Computer and Power supply blocks which interact with each other. Then the Zigbee at monitoring section will receive the signal and send to computer through serial communication circuit.

Fig 2: Monitoring Section

III. MINE SECTION

We believe a network composed of N fixed and identical sensors which are placed on a rectangular 2-D grid. The sensors are equipped with Omni directional antennas that have a maximum transmission range of r meters. The horizontal and vertical axes are represented by ξ and η, respectively. To simplify analysis, we uniformly (and logically) sample both axes and treat ξ and η as discrete variables. Each discrete (ξ, η) position is referred to as a segment. Let l and h denote the length and height of a segment, respectively. Here, it should be emphasized that this segmentation is only logical with just one constraint: r _ $l \times h$. Due to this constraint, a sensor in segment (ξ, η) can receive traffic from sensors in the same seg-ment (ξ, η) or (at maximum) from sen-sors in neighboring segments of (ξ, η). The neighboring segments of segment (ξ, η) are shown in Figure 1.

The distribution of sensors on the grid is governed by a 2-D, discrete-time random process _ (ξ, η). Each con-stituent random variable of _ (ξ, η) describes the number of sensors in the (ξ, η) segment. The random variables of _ (ξ, η) are assumed to be independent and identically distributed (IID). Using the IID assumption, let E{_ (ξ, η)} = μ_D represent the expected value of _ (ξ, η) for any ξ, η. Then, on-average, we have average number of nodes per segment = μ_D. (1)

We assume that the sensors in a segment are distributed (located) uniform-ly within the borders of the segment.

Figure 1 outlines the fact that, due to the r _ $l \times h$ constraint, sensors on the edges of a segment can communicate with sensor in parts of the neighboring segments. In essence, a sensor in segment (ξ, η) can only communicate with sensors inside the thick, broken line of Figure 1. For instance, the sensor located at the corner of the (ξ, η) segment can at most send/receive traffic to/from sensors within its transmission range, as represented by the circle in Figure 3.

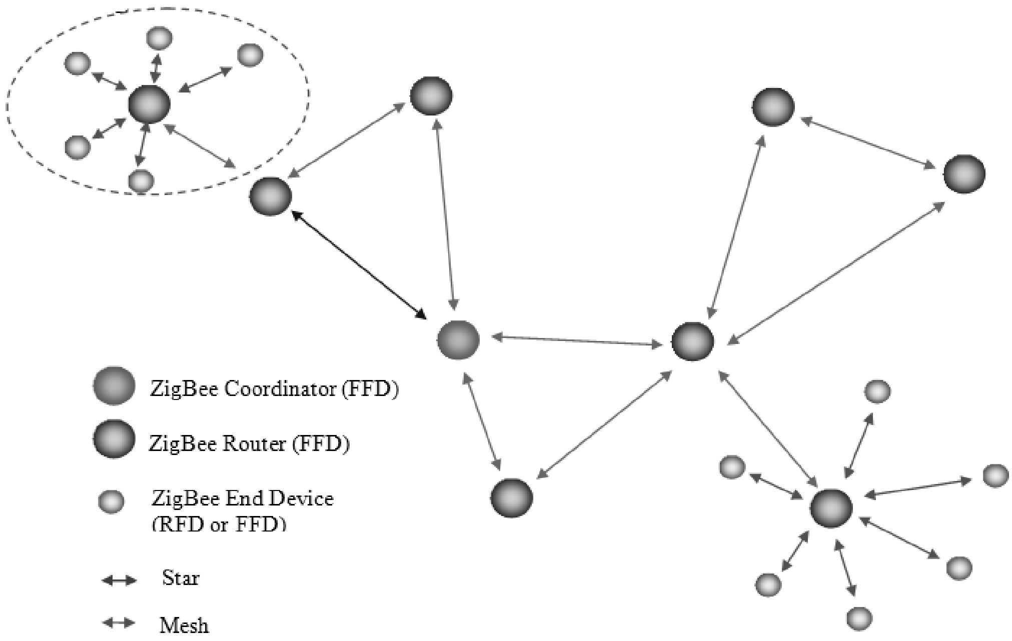

Fig 3: Wireless sensor Network Model

3.2 Neighbor Node Distance calculation

In Figure 1, the distance d between two nodes A and B is to be estimated. Let A and B be the region of communication circles of node A and node B respectively. The common region of region A and B is X. Also, let there be na nodes in A, nb nodes in B, and nx nodes in X. Intuitively, when d is small, nx is large and na and nb are small. Conversely, when d is large (A and B within communication range), nx is small, while na and nb are large. Hence, by taking into account the values of na, nb and nx, d can be estimated.

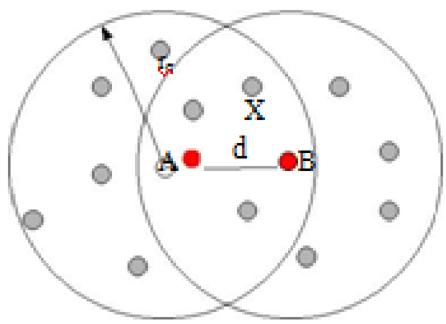

Fig 4 : The number of common neighbors of two nodes can be used to estimate the distance between the two nodes.

Maximum likelihood estimation is used to estimate the size of X and thus the distance d. The probability of having certain number of nodes inside an area given the value of the area is given in Equation 2.

$$p(N_A = n) = e^{-\lambda A}(\lambda A)^n \quad (2)$$

Since there is no condition that the next hop should exist for the last hop N, the pdf of the last-hop maximum distance rN is obtained as follows:

$$g(r_N) = \sigma\alpha r_N e^{-\frac{\alpha\sigma(R^2 - r_N{}^2)}{2}},$$
$$p_{\mathbf{r_N}}(r_N) = \frac{g(r_N)}{\int_{r_{eq}(\overline{r_{N-1}},\theta_{N-1})}^{R} g(r_N)\mathrm{d}r_N}. \quad (3)$$

Using (3), the expected value and the second moment of the last hop are found, as given by (4) and (5). Note that the variance of the last-hop distance is

$$\sigma^2_{r_N} = E[\mathbf{r}^2_{\mathbf{N}}] - E[\mathbf{r_N}]^2$$

Where

$$E[\mathbf{r_N}] = \frac{1}{\alpha}\int_{-\frac{\alpha}{2}}^{\frac{\alpha}{2}}\int_{r_{eq}(\overline{r_{N-1}},\theta_{N-1})}^{R} r_N p_{\mathbf{r_N}}(r_N)\mathrm{d}r_N\,\mathrm{d}\theta_{N-1}, \quad (4)$$

$$E[\mathbf{r}^2_{\mathbf{N}}] = \frac{1}{\alpha}\int_{-\frac{\alpha}{2}}^{\frac{\alpha}{2}}\int_{r_{eq}(\overline{r_{N-1}},\theta_{N-1})}^{R} r_N{}^2 p_{\mathbf{r_N}}(r_N)\,\mathrm{d}r_N\,\mathrm{d}\theta_{N-1}. \quad (5)$$

3.3 Algorithm for wireless sensor network

The base station (BS) initiates the routing process. Election a cluster-head in each round with an energy value greater than ten percent of the residual value at each sensor. After selection of the head. Wait for member nodes. Create the table TDMA and sent it to members. Launch of the transmission phase. If the energy is less than its value in second steps, the process of LEACH will be launched. Our approach is summarized in figure 4.

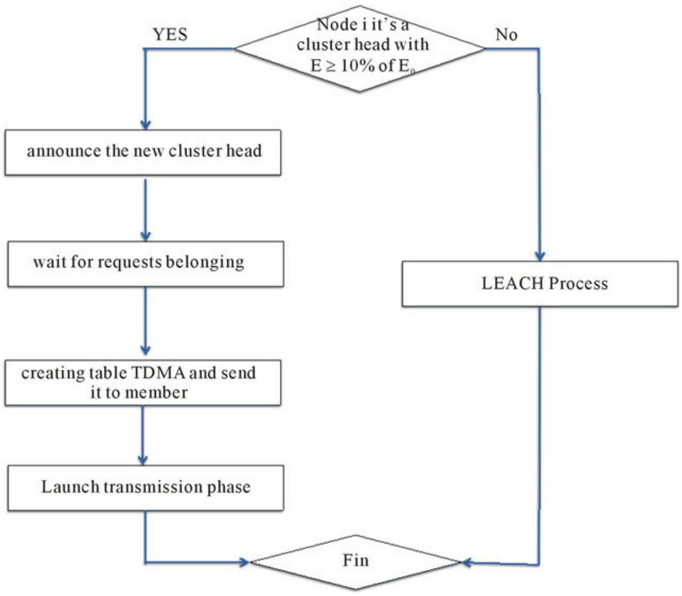

Figure : 5 Algorithm Diagram

3.4 Power consumption in wireless sensor Network

In microcontroller level this transition of states it is represented by different power mode that shutdown the CPU, memory or additional internal peripherals. It is worth to say that each transition of state takes a certain amount of time and consequent energy consumption as reported in Figure 5. In each power mode, also called low power mode (LMP), different peripherals are incrementally turned off. Each transition from the idle state to a LPM has a fixed cost, indicated in Figure 5 as *b0*, which is usually negligible. However the energy cost for waking up the microcontroller from a low power mode increases with the depth of the low power modes. For this reason it is important to reduce the number of state transitions, conveniently balancing the scheduling mechanism without using aggressive power down strategies.

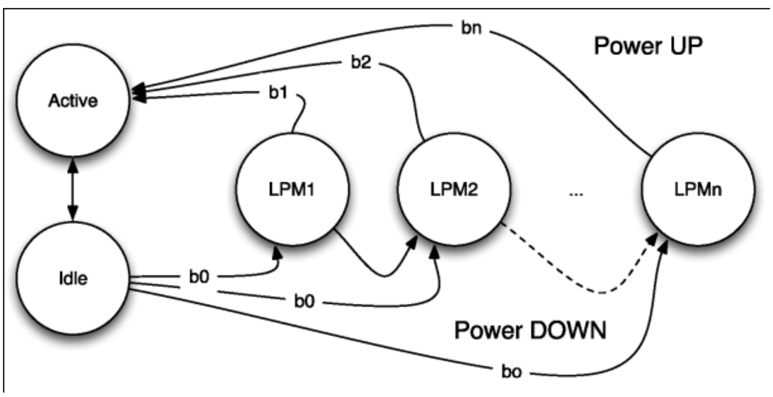

Figure 6: Low Power Mode Transition and Cost.

Active power conservation mechanisms differ from passive ones in that they achieve a reduction of the energy consumption by avoiding undesired events like collisions, or exploiting energy-aware routing protocols. For instance adjusting the transmission power may help minimizing the probability of occurrence of a collision, an event leading to higher power consumption due to the related detection and retransmission activities. A very common solution is the series insertion of a small resistance R_1 ($\leq 10\Omega$) between the power supply and the Device Under Test (DUT), as shown in Figure 6.

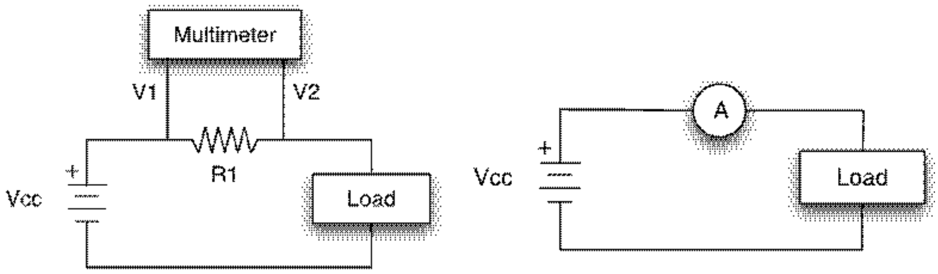

Figure7 Measurement setup with a shunt resistor.

Then, by measuring the voltage drop $\Delta V=V_2-V_1$ across the resistor, current I can be measured indirectly, using Ohm's law, as

$$\hat{I}=\Delta VR1=V2-V1R1 \qquad (1)$$

3.5 Routing techniques in wireless sensor network

Direct Diffusion - In Direct Diffusion, sensors measure events and create gradients of information in their respective neighborhoods. The base station requests data by broadcasting interests. Interest describes a task required to be done by the network. Interest diffusion through the network hop-by-hop, and is broad-cast by each node to its neighbors. As the interest is propagated throughout the network, gradients are setup to draw data satisfying the query towards the requesting node, i.e., a BS may query for data by disseminating interests and intermediate nodes propagate these interests. Each sensor that receives the interest setup a gradient toward the sensor nodes from which it receives the interest. This process continues until gradients are setup from the sources back to the BS. More generally, a gradient specifies an attribute value and a direction. The strength of the gradient may be Direct Diffusion towards Different neighbors resulting in different amounts of information flow. At this stage, loops are not checked, but are removed at a later stage. Figure 3 shows an example of the working of directed diffusion ((a) sending interests, (b) building gradients, and (c) data dissemination). When interests fit gradients, paths of information flow are formed from multiple paths and then the best paths are reinforced so as to prevent further flooding according to a local rule. In order to reduce communication costs, data is aggregated on the way. The goal is to find a good aggregation tree which gets the data from source nodes to the BS. The BS periodically refreshes and re-sends the interest when it starts to receive data from the source(s). This is necessary because interests are not reliably transmitted throughout the network.

3.6 Temperature sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

The LM35 does not require any external Calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air.

3.7 Gas sensor

Gas sensor is used in gas leakage detecting equipments in family and industry, are suitable for detecting of LPG, iso-butane, propane, LNG, avoid the noise of alcohol and cooking fumes and cigarette smoke.

Fig 7: Gas sensor

It has some features like, High sensitivity to LPG, iso-butane, propane, small sensitivity to LPG smoke, Fast response, Stable and long life, Standard detecting conditions

3.8 Humidity sensor

The Smartest humidity sensor is a two terminal capacitor, which increases in value as water molecules are absorbed into its active polymer dielectric. It has some features: high performance, long term stability, close tolerances, reliable construction and low cost. Applications: Air conditioners, Climate control for green houses, Storage and warehouses, meteorological applications, Food processing, Room comfort control, medical applications.

3.9 play back circuit

The APR9600 device offers true single-chip voice recording, non-volatile storage, and playback capability for 40 to 60 seconds. The device supports both random and sequential access of multiple messages. Sample rates are user-selectable, allowing designers to customize their design for unique quality and storage time needs. Integrated output amplifier, microphone amplifier, and AGC circuits greatly simplify system design. The device is ideal for use in portable voice recorders, toys, and many other consumer and industrial applications.

APLUS integrated achieves these high levels of storage capability by using its proprietary analog/multilevel storage technology implemented in an advanced Flash non-volatile memory process, where each memory cell can store 256 voltage levels. This technology enables the APR9600 device to reproduce voice signals in their natural form. It eliminates the need for encoding and compression, which often introduce distortion.

IV. MONITORING SECTION

Monitoring system has a ZigBee, and computer.

4.1 ZigBee

This is an FSK Transceiver module, which is designed using the ChipconIC (CC2500). It is a true single-chip transceiver; it is based on 3 wire digital serial interface for precise local oscillator generation. So the frequency could be setting. It is a high performance and low cost module. It gives 30 meters range with onboard antenna.

In a typical system, this trans-receiver will be used together with a microcontroller. It provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication and wake on radio. It can be used in 2400-2483.5 MHz ISM/SRD band systems. (e.g. RKE-two way Remote Keyless Entry, wireless alarm and security systems, AMR-automatic Meter Reading, Consumer Electronics, Industrial monitoring and control, Wireless Game Controllers, Wireless Audio/Keyboard/Mouse). It could easily to design product requiring wireless connectivity. Operating Range is 30 meters without requiring any external antenna.

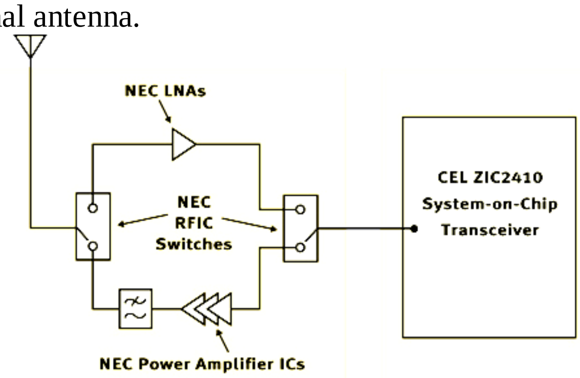

Fig 8: ZigBee

Computer is used to store data from the receiver. Software, developed here is to make an interactive, reliable monitoring and management of sensed data. The different environmental parameters received by the ground control PC are displayed in those manners in the LCD screen. The parameter used with the sensors to receive the sensor outputs and to take the necessary decision. The microcontroller can store data's as required by the user for maintaining of records.

Once temperature is more than the safety level preprogrammed at microcontroller, microcontroller decodes beep alarms through the speaker and LCD connected with. Again, once the measured humidity value is more than the safety level preprogrammed at microcontroller, it decodes different type message. Similarly when gas concentration crosses the safety level, microcontroller decodes message. In all such cases, this will send an alarm through an urgent message and alarm sound to the ground control terminal through zigbee.

Second section is hardware and software that will be placed in ground terminal. Based on the alarm received ground staff takes decision and establish voice communication with the underground workers. The safety department people are sent alarm. Respective control and safety measures are taken accordingly based on the continuous monitoring of situation and voice communication with underground people. include the temperature, humidity, and gas. The computer stores the parameters in the hard disk and ground staff can choose any of the parameters for recording and replaying.

V. SAFETY SYSTEM FOR MINE WORKERS

The developed system can be divided into two sections.

First is a hardware circuit that will be attached with the body of the mine workers. This may be preferably fitted with the safety helmet of the workers also which should be mandatory in the premises of any underground mines. An additional stand by system can be fitted with the wrist of the underground mine workers if required. The circuit has a sensor module consisting of some MEMS based sensors that measures real-time underground parameters like temperature, humidity concentration of different gases inside mines etc. Gas concentration is meant for the harmful gases. Some of the gases are toxic and some are inflammable. Here we used power consumption in wireless sensor network based on the transition to the sensor node energy and also implement Direct diffusion routing technique is used to find the shortest path as well as minimum cost to improve sensor node performance.

VI. CONCLUSION

Traditional mine security system can be effectively replaced by the surveillance and safety system proposed in the paper. This paper gives a system related to safety and security of underground mines. The system is reliable, faithful, uninterrupted, economical and user friendly. A larger area and more depth inside hazardous underground mines are now can be covered and potential accidents can be controlled effectively.

The system combined the low power, low cost Zigbee based high frequency wireless data transmission technology. The sensor and zigbee module can be preferably installed over the helmet of mine worker. Proper monitoring and conversation is possible between the workers and the ground staff which can help to take appropriate actions more rapidly and smartly. The system also can be easily extended with ZigBee wireless image transmission facility in future; it will improve scalability of underground environment and extend accurate position of miners.

REFERENCE

[1]. Mineral Industry Safety and Health Centre (2012). ‘Compliance gate database’, http://www.mirmgate.com.au/index.php?gate=compliancegate. Accessed 8/1/12

[2]. NSW Department of Primary Industries (2007). “Preparing a health and safety management system”, http://www.dpi.nsw.gov.au

[3]. National Research Centre for OHS Regulation (2012), “About occupational health and safety regulation in Australia”, http:// ohs.anu.edu.au/ohs/index.php

[4]. Robens L, (1972). “Report of the Committee on Safety and Health at Work”, London: Majesty’s Stationery Office.

[5]. Step Change in Safety (2011) “Leading Performance Indicators”, http://www.stepchangeinsafety.net accessed 8/1/12

[6]. D. Moore, J. Leonard, D. Rus, and S. Teller, “Robusted distributed network localization with noisy range measurements,” in Proceedings of ACM SenSys’04, 2004.

[7]. C. Shannon and D. Moore, “The spread of the Witty worm,” IEEE Security & Privacy, vol. 2, no. 4, July/Aug. 2004, p. 46–50.

[8]. S. Vural and E. Ekici, “Probability Distribution of Multi-Hop- Distance in One-Dimensional Sensor Networks,” Computer Networks: The Int’l J. Computer and Telecomm. Networking, pp. 3727- 3749, Sept. 2007.

Authors Biography

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