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Framework for Implementing Load Balancing Within Cluster in Underground Mining Environments

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Abstract: Underground mines are more hazardous in nature and always contain unsafe for their workers. Underground mining causes huge losses due to accidents and disaster. There is the need to develop an effective, secure, reliable and low-cost surveillance and safety system in underground mine environments. Wireless Sensor Networks (WSNs) are increasingly being used for such application. Since wireless sensor nodes are highly energy constrained devices and they have limited battery life due to various constraints of sensor nodes. Therefore, optimal usage of node energy is the major challenge in wireless sensor networks. Clustering of sensor nodes is an effective method to use the node energy optimally and prolong lifetime of such energy constrained wireless sensor networks. Here we propose a framework for load balancing within clusters in the underground mine environment. The proposed clustering algorithm ensures balanced size cluster formation and it has been proposed to achieve balanced energy consumption among nodes. This project aims to give a secure and efficient communication for the underground are using these respective sensors and here a concept of cluster and their rotation is implemented so that the loss of signals can be restricted and helps in a secure communication
Keywords: component, formatting, style, styling, insert (key words)

I. INTRODUCTION

Underground mines are more hazardous in nature and always contain unsafe for their workers [33]. Underground mining causes huge losses due to accidents and disaster. There is the need to develop an effective, secure, reliable and low-cost surveillance and safety system in underground mine environments [33]. Wireless Sensor Networks (WSNs) are increasingly being used for such application. Since wireless sensor nodes are highly energy constrained devices and they have limited battery life due to various constraints of sensor nodes . Therefore, optimal usage of node energy is the major challenge in wireless sensor networks [2]. Clustering of sensor nodes is an effective method to use the node energy optimally and prolong lifetime of such energy constrained wireless sensor networks .Here we propose a framework for load balancing among clusters in the underground mine environment. The proposed clustering algorithm ensures balanced size cluster formation and it has been proposed to achieve balanced energy consumption among nodes [34].

Technological advancements and stricter regulations have helped in controlling the accident rate in underground mines, still hundreds of people lose their lives and huge financial losses are incurred to mining industry each year from mining disasters [31]. In the classification of mine accidents issued by Mine Safety and Health Administration of the U.S. Department of Labor, the major causes apart from faulty equipment, structure failure, and personal negligence are explosions, roof falls, fires, and accumulation of gases [32]. In a report published by Centers for Disease Control and Prevention, a total of 11,606 underground coal workers died in 513 disasters in the USA from 1900 to 2006, with most disasters resulting from explosion or fire. Proper ventilation and regular inspection of hazardous gases is required or in other words environmental monitoring and contemphasized to avoid accidents in underground mines [31]. However, monitoring of such harsh environment is not an easy task and even if human negligence is completely avoided, dynamic nature of the environment calls for an automated, intelligent, and reliable monitoring system. Typical underground mine consists of stretches of kilometers long tunnels with excavation branches spreading out like a tree. This means the monitoring system should be scalable, easily deployable, and have low-maintenance cost to increase coverage as the mine grows. The tunnels normally have very rough terrains, i.e., a very harsh environment for radio frequency (RF) communications [31]. The communication scheme in such environment must be robust to blockages and redundant to node failures. The mine environments are typically quite dynamic; attributes may change instantly calling for immediate evacuation in a rare case of event contrary to a normal condition lasting for weeks and months [6]. Therefore, the solution must be responsive in case of events and energy efficient during normal operating conditions.

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In addition, there may be cases of events that are confined to a part of the mine and do not pose a threat to people working in other areas. Therefore, the solution must have a central server capable of inferring the global picture in conjunction with a distributed system required for energy-constrained sensing network [36]. In case of accidents, localization of events and miners is of key importance [12]. Activity monitoring of miners can also provide useful information at times. The most important thing is the seamless integration of all the subsystems into a complete monitoring system [28]. This paper presents a unique and comprehensive monitoring and control system for harsh environments. It is based on an application-specific communication protocol, utilizing known network topology to design energy-efficient routing and collision-avoidance (CA) mechanism [4]. RF modeling is used for optimum node placement and reliable connectivity. The system has integrated an intelligent anomaly detection mechanism that not only has the capability to detect and identify events in real time but also has the memory to cater for the spatio-temporal dynamics of the environment [29]. The solution is distributed (takes care of the spatial dynamics) where individual nodes have the capability to detect local events but also carry out periodic reporting so that the central server has the global picture. In addition, localization of miners and events and roof falls, etc., has been integrated in the system.

II. EXISTING SYSTEM

An existing approach for mine monitoring has been presented in Fig 1[36]. For the base protocol, most works have relied on ZigBee for its ease of deployment, low data rate (250 KB/s), substantial range and most importantly low power consumption when compared to other technologies such as Wi-Fi, Bluetooth and ultra wideband communication [35] .

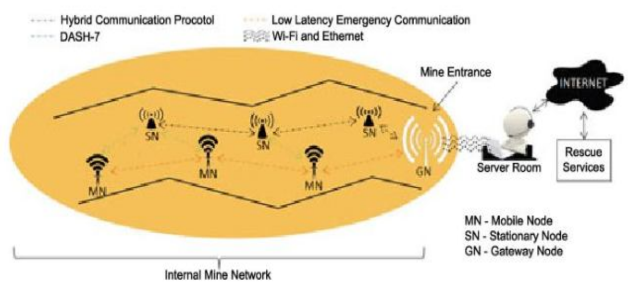

Fig. 1 System Architecture

However, it gives an even lower data rate and lower frequency protocol, DASH-7[27]. Due to the simple direct energy-bandwidth relationship; lower data rate projects better energy efficiency and lower frequency promises higher range. Also, ZigBee is a general purpose protocol. Although nodes can be configured to some extent, the nodes are randomly deployed and the network is formed and operates dynamically [5]. This means that it does not benefit from known characteristics such as signal attenuation, network topology, and routing. Connection is established using carrier sense mechanism which increases delays, uncertainty, and power usage [15]. Nodes are set to specific roles such as cluster heads and sensor nodes, which reduce flexibility [30]. Even dynamic routing between randomly distributed nodes in a big network can be complex and energy-consuming and may lead to areas with redundant or weak coverage's (specially without signal attenuation consideration) [2]. An application-specific approach can benefit from known facts and answer all these challenges. The review in also points out that some works have focused on simulations while not giving enough consideration to power requirements for long term operations and did not present experimental results [26] . Finally, although existing works emphasize reliability, not a lot has been researched on run time intelligent decision making capability for reliable event detection [3]. Authors in and emphasize the need for data collaboration between nodes and intelligent processing for efficient decision making but their scope is limited to energy saving and gas concentration detection, respectively. Unlike previous works targeting a single aspect of system, this paper takes an integrated approach, improving separate subsystems and taking advantage of dependability of various subsystems [34]. The system consists of three types of devices: mobile node (MN), stationary node (SN), and gateway node (GN). Each type of device runs its specific firmware and communicates, via set communication protocol. The usual practice for monitoring in WSNs is to have an event triggered design, i.e., communication between the sensor nodes (SNs and MNs) and the sink node (GN) is required only if an anomaly occurs or the server initiates a query. Although this approach saves energy, but there is a danger of missing trends.

Mobile nodes (MN) which is Carried by miners and Capable of monitoring miner activity and Sense parameters critical for miner's survival inside the mine (e.g. temperature, humidity, and oxygen levels),Convey information to the nearest SN, Can also send distress signal(s) to the gateway, Can run miner localization algorithm, Charged by Li-Po batteries[7]. Stationary Nodes (SN) At an appropriate distance from each other, Sense different parameters critical to structural integrity of the mine, Roof fall, temperature, humidity, and concentration of toxic gases such as CO Run local event detection and identification algorithm. Each acts as a cluster head forward received data to the GN and Communicate with MNs using DASH-7[8]. Gateway Node (GN) and BS Collects data from SNs in its vicinity using custom designed protocol and Sends it to the server/BS via Ethernet or Wi-Fi. At BS, data received from GN can be visually analyzed

III. PROPOSED SYSTEM

A patient is the main source of information/data through various sensors [11]. The data gathered from sensors are stored in a remote location where it can be used to generate several reports as per need. The sensor nodes in a MWSN are typical sensor nodes. But these nodes are well configured to work with necessary medical equipment for vital signs monitoring. This data can be transferred to remote locations through base stations [10]

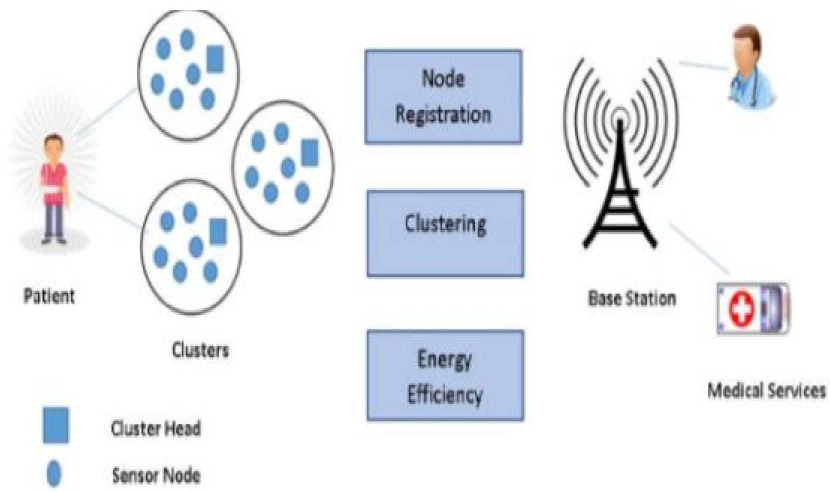

Fig. 2 Proposed System

The data is configured in the form of a file set as an AVP (Attribute Value Pairs) value [36]. The configuration file has standard and default information of heart rate, pulse rate and blood pressure, default ID, battery, and temperature information. The values are set to verify the node [12]. The configuration file can easily be accessed through a firmware and is vulnerable to attacks. Hence it is important to ensure integrity of this file [25]. It presents 3-tier architecture to address issues in trust management, security, and privacy in MWSNs. The sensor nodes in this architecture can continuously update their configuration and trust level to avoid being malicious [8]. They continue to transmit usable, private and sensitive information as well [24]. The 3-tier architecture is based on initial configuration of the wireless sensor nodes. Sensor nodes can continuously Update configuration and trust level, Avoid being malicious and Records initial configuration and saves it in separate file in encrypted form and Used for energy efficient communication Cluster heads are changed continuously to divide network energy computation overhead among the nodes[36].

To overcome the shortcomings of wired systems, two-leveled network architecture for the WSN is proposed under an integrated monitoring system, com- binning WSN and existing wired monitoring system. It discusses only the topology generation algorithm and monitoring mechanism for the system[9]. Again, a low power WSN is proposed based on the low energy adaptive clustering hierarchy protocol. According to the structure condition of coal mines, WSN is divided into two categories, one of which includes all the nodes in a cluster (CN) and the other is composed of all the cluster heads (CH). The difference between CH and CN mainly lies in their software.

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The communication between CH and CN is based on direct sequence spread spectrum. All the CNs in a cluster use different random frequency that leads to avoid the interference within the cluster. Every node can collect data and CN send its data to the CH. The proposed two-level network is shown in Fig. 3.

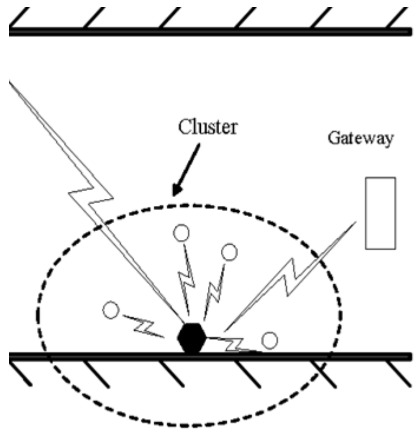

Fig 3 Two- levelled network

The objective of the proposed method is to prolong the lifetime of WSN by appropriately rotating the CH role among smart sensor nodes. It should be kept in mind that the considered WSN lifetime corresponds to time interval before death of the first sensor node [36].The problem of achieving maximum WSN lifetime is illustrated in Fig 3.4 for a network composed of three sensor nodes[13]. The examples shown in Fig 4 (a, b) assume that both nodes have the same initial energy level (energy = 100 for time = 0). In the example from Fig 3.4 a) a static assignment of the CH role is considered, i.e., node 1 takes the CH role for the entire analyzed period. Thus, the residual energy of node 1 decreases faster than the energy of node 2and 3[14]. As a result, node 1 dies after 400 cycles, while node 2and3 has still some units of energy (it should be noted that time in Fig 3.4 is expressed in cycles of sensor node operations). The lifetime of WSN in this example equals 400 cycles [15].

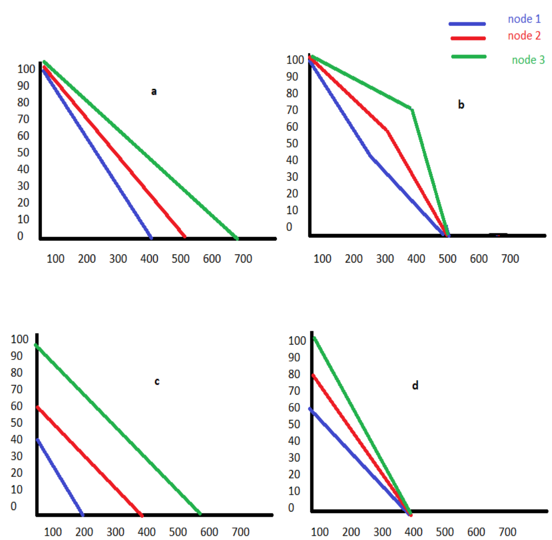

Fig 4 Cluster head rotation

The second example Fig 3.4 b shows that the lifetime of WSN can be extended by changing the sensor node, which takes the CH role [19]. In this example, node 1 takes the CH role for cycles 0–249, and then the CH role is performed by node 2. Both sensor nodes 1, 2, 3 deplete their energy at the same time step, It means that lifetime of the WSN is prolonged to 500 cycles [20]. The lifetime of 500 cycles is the maximum time for the considered WSN example. It should be noted that the maximum lifetime is achieved when both sensor nodes die at the same time step [36].

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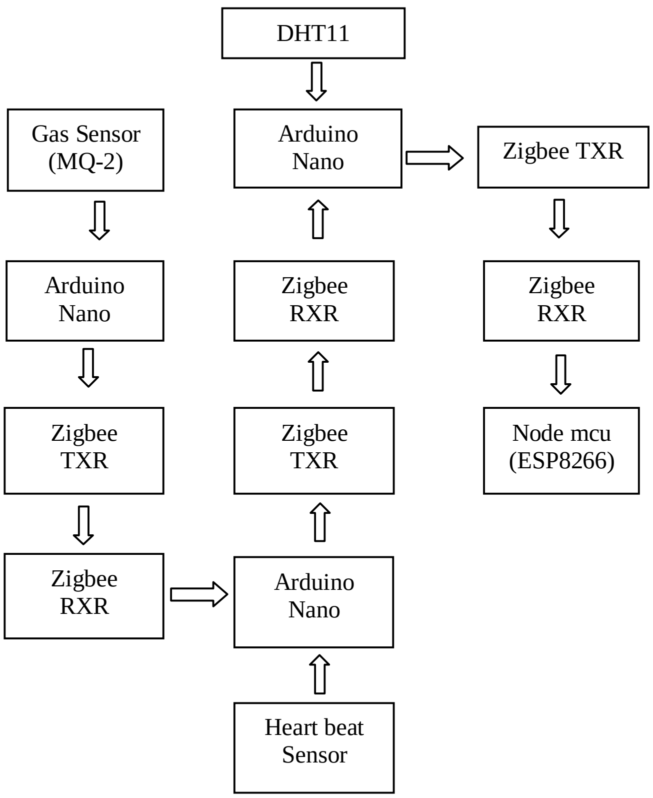
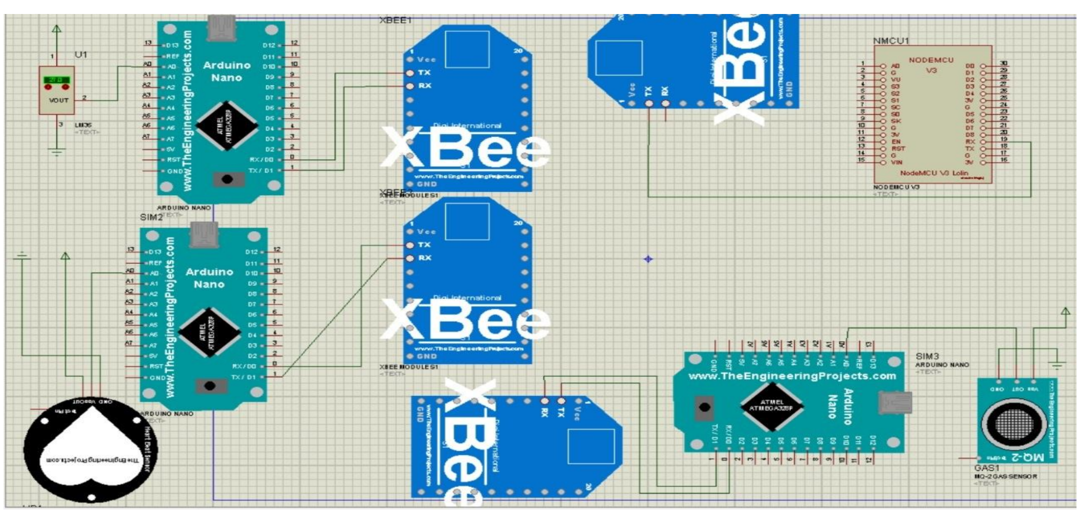
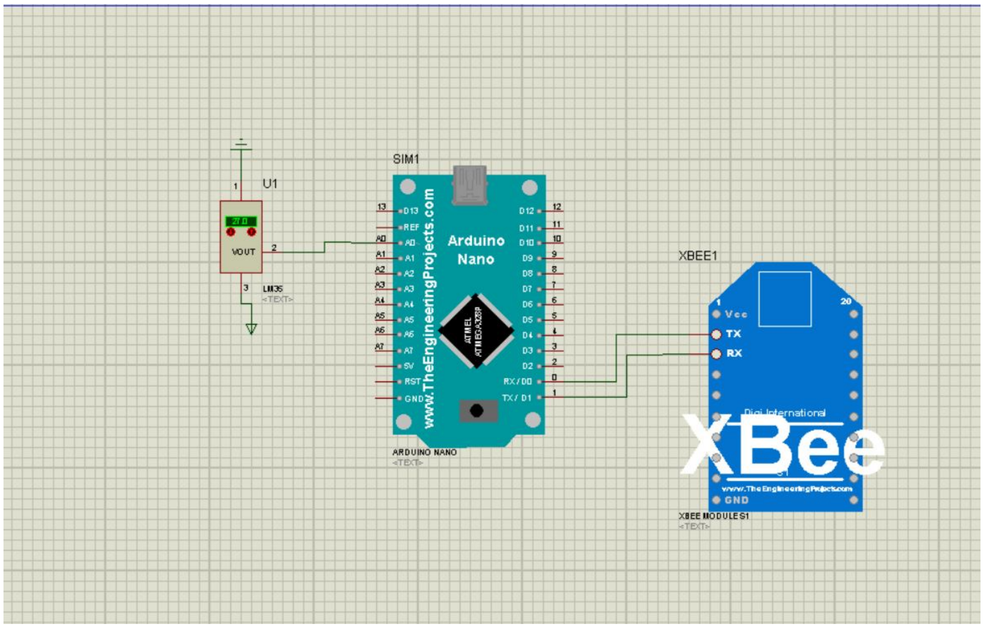
Lifetime of the WSN for different initial energy levels of sensor nodes is analyzed in Fig 3.4 c, d). In these examples the initial energy equals 100 units for sensor node 1 and 60 units for sensor node 2. Fig 3.4 d) shows that without CH role rotation (node 1 is CH) both nodes die simultaneously after 400 cycles of the WSN operation [21]. Thus, for the above-mentioned levels of initial energy the maximum WSN lifetime is equal to 400 cycles [16]. In Fig 3.4 c) the change of CH node after 250 cycles results in decreased WSN lifetime, as node 2 depletes its energy approximately at cycle 330.and after the interval node 3 will be the head [22].

When analyzing the examples Fig 3.4 b, d) it can be observed that the WSN lifetime is maximized if both nodes die at the same time[17]. This observation is also confirmed by conclusions of the related works, where more complex scenarios were considered than those discussed above[18]. Therefore, the general rule can be formulated that energy consumption of sensor nodes has to be balanced to prolong the WSN lifetime [23].



IV. IMPLEMENTATION AND RESULT




SIM1
U1
VOUT
Arduino
Nano
www.TheEngineeringProjects.com
ARDUINO NANO
XBEE1
Vcc
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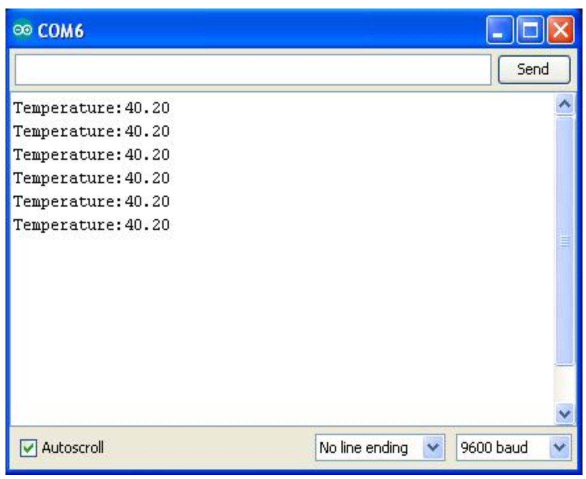
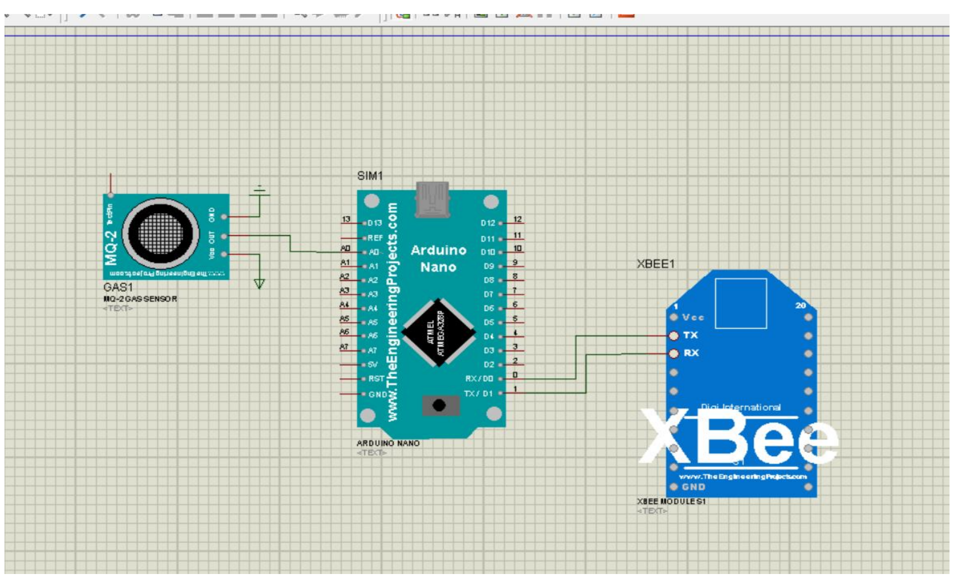
XBee
XBEE MODULE S1


COM6
Send
Temperature:40.20
Temperature:40.20
Temperature:40.20
Temperature:40.20
Temperature:40.20
Temperature:40.20
Autoscroll
No line ending
9600 baud


SIM1
MQ-2
GAS1
MQ-2 GAS SENSOR
Arduino
Nano
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ARDUINO NANO
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Vcc
TX
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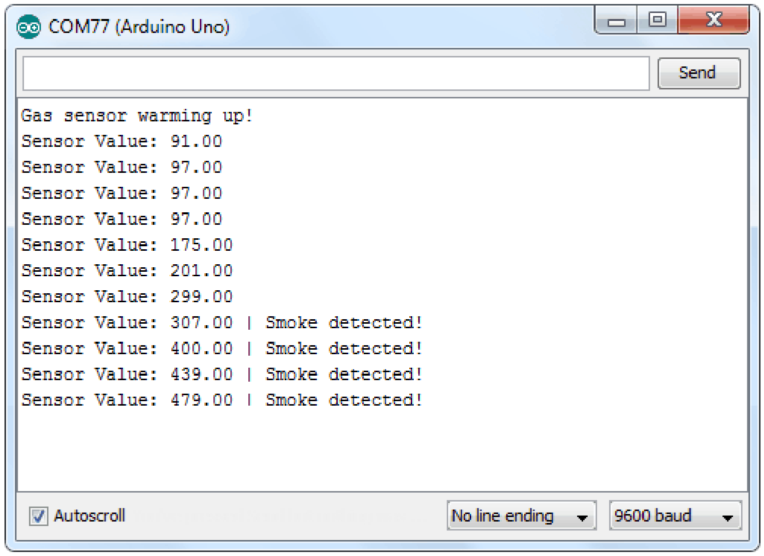
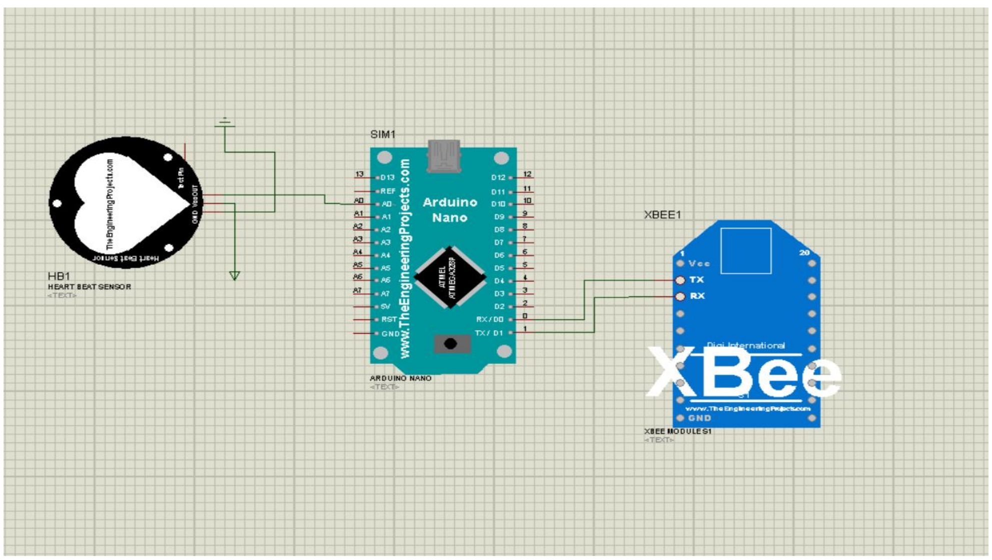
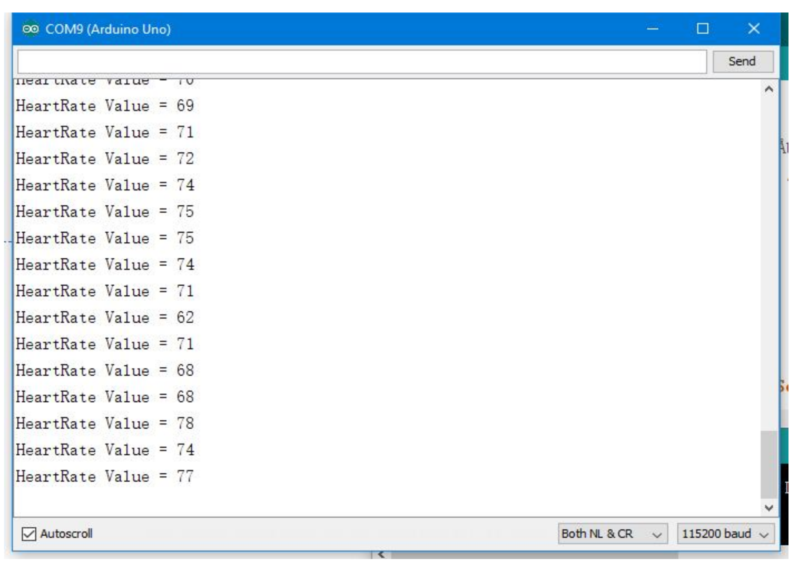
GND
XBee
XBEE MODULE S1


COM77 (Arduino Uno)
Send
Gas sensor warming up!
Sensor Value: 91.00
Sensor Value: 97.00
Sensor Value: 97.00
Sensor Value: 97.00
Sensor Value: 175.00
Sensor Value: 201.00
Sensor Value: 299.00
Sensor Value: 307.00 | Smoke detected!
Sensor Value: 400.00 | Smoke detected!
Sensor Value: 439.00 | Smoke detected!
Sensor Value: 479.00 | Smoke detected!
Autoscroll
No line ending
9600 baud


SIM1
Arduino
Nano
www.TheEngineeringProjects.com
HB1
HEART BEAT SENSOR
ARDUINO NANO
XBEE1
Vcc
TX
RX
GND
XBee
XBEE MODULES1


COM9 (Arduino Uno)
Send
HeartRate Value = 69
HeartRate Value = 71
HeartRate Value = 72
HeartRate Value = 74
HeartRate Value = 75
HeartRate Value = 75
HeartRate Value = 74
HeartRate Value = 71
HeartRate Value = 62
HeartRate Value = 71
HeartRate Value = 68
HeartRate Value = 68
HeartRate Value = 78
HeartRate Value = 74
HeartRate Value = 77
Autoscroll
Both NL & CR
115200 baud

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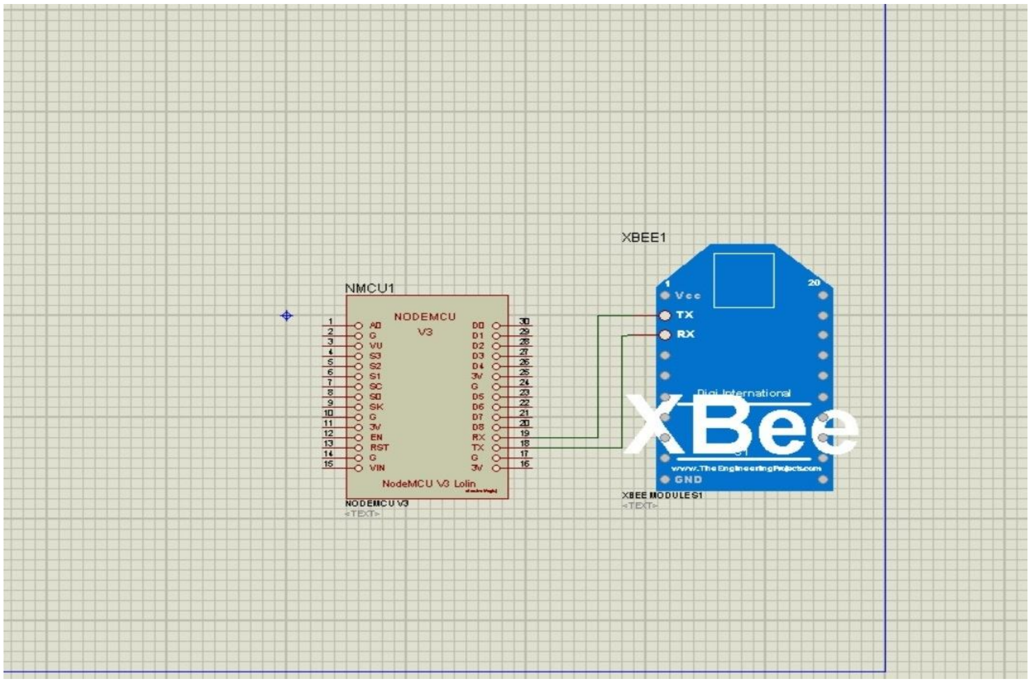

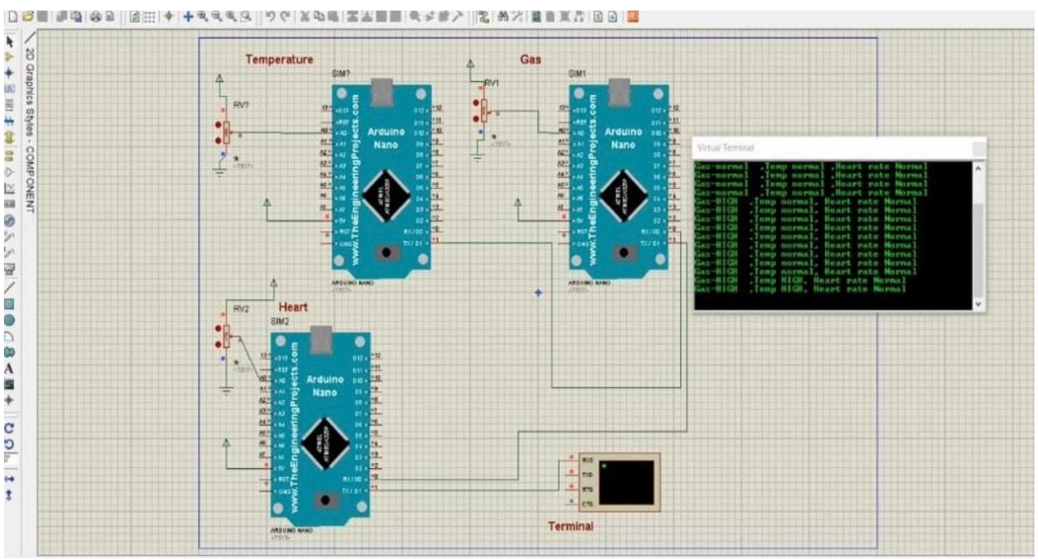

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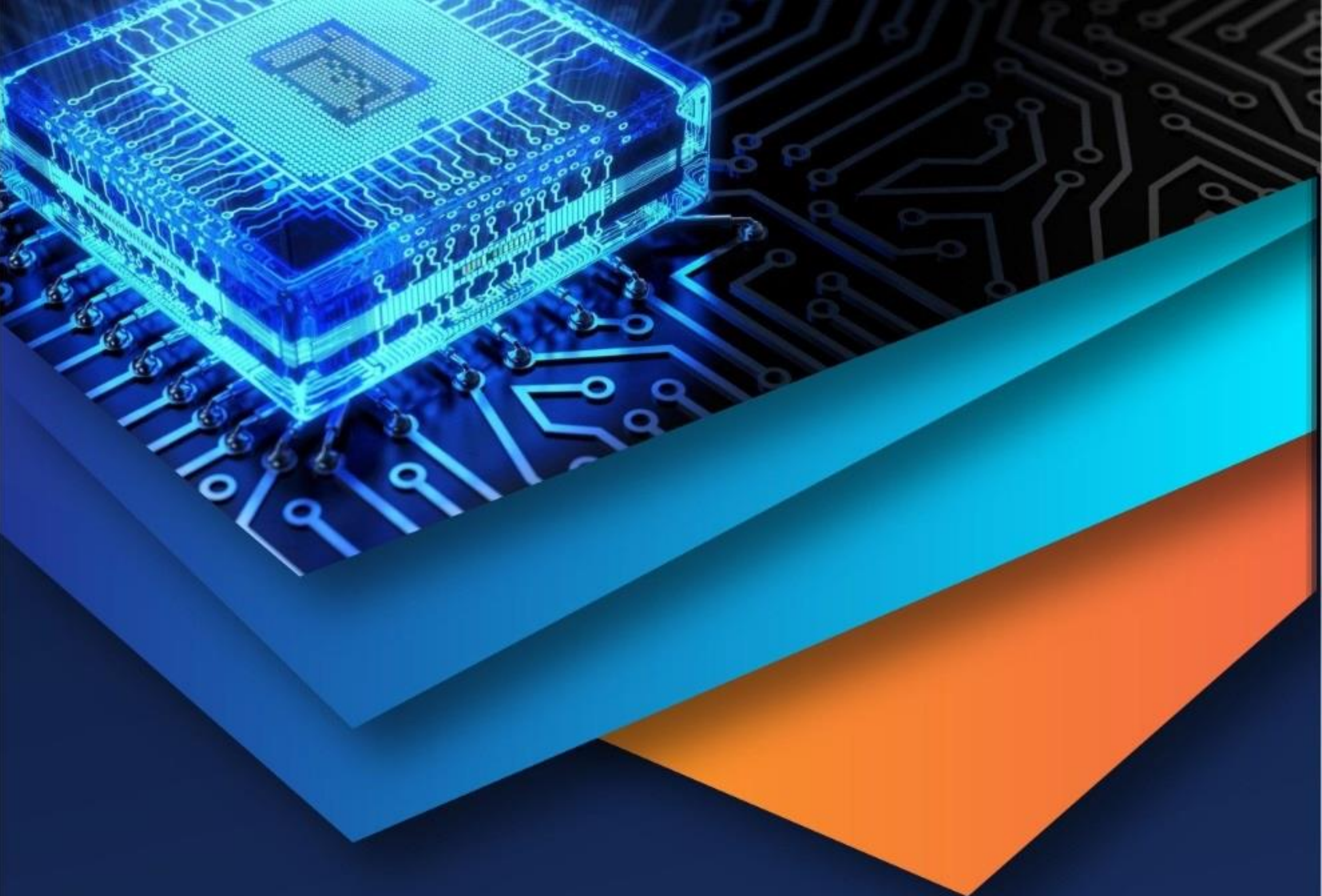
[35] Web of Things-Based Remote Monitoring System for Coal Mine Safety Using Wireless Sensor Network
[36] A Cluster Head Rotation method Based Energy Efficient Trust Management Mechanism for Wireless Sensor Networks



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