International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Development of a WSN Framework for Mining & Civil Safety Monitoring Purposes

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Abstract*: In this paper we describe the development of an IEEE 802.15.4 compatible wireless sensor network (WSN) node for mining & civil safety protocols. The sensor node will acquire and internally store data of sensors periodically. Starting times as well as the time intervals for the measurements can be freely programmed over the network system. As soon as an obstacles is detected in its proximity the node will automatically transfer data. Optionally sensor data can be delivered on demand. When in its idle state the node remains in power-down mode in order to minimize power consumption. Secondly attempt can also be make in this work that to generate the alerts as per settable range of unhealthy conditions. In normal Industrial data transfer environments standard current loops of 4mA-20mA or standard voltage loops of isolated 12V, 24V & 36v are used. But all these methodologies are associated with the long distance & short distance wired topologies. As wired communications are costly & needs the frequent maintenance cost appointments their forms the need of development of suitable profile with suitable data rates. The profile here developed form the unique wireless link using Wireless for such inter analog & digital data transmissions*.

Keywords: wireless sensor network, mine safety, network topology, zigbee

1. Introduction

Mining/civil automations which are mostly depend upon the power systems & which requires distance controlled and regulated systems. Mostly voltage and current equipped parameters along with power and energy management system forms the industrial scenario for automations. Wired system with analog and digital control systems have traditional drawbacks influenced by distance communication techniques. These systems are also sustainable for early noise effects and data corruptions, due to which some unexpected behavior may occur in power system which again may lead to serve effect like production failure; secondly development cost for such system again hits the cost performance ratio in adverse mannerism. To overcome & conquering to such unhealthy and miserable functioning properly managed wireless system will always prove to be gift hand for industry. In the recent research field which focused on numbers of wireless technologies, a technology which meets to cost, speed and distance scenario will always be a point of an interest for research. Standardization of technology again plays an important role for globalization of these profile developments. Wireless due to its standardize operational and network management properties will be suitable wireless interface technique, Wireless also have low data rates over a middle distance and AES encryption properties which are again guaranteed for required communication scenario. In this Project work we will mainly monitor power related parameters with temperature & distance level and enable remote switching device for proper power management systems, part of research also employ multi switching properties in order to cost redundancy with reduce network management efforts.

2. Literature Review

Pranoti Anandrao Salankar1, Sheeja S. Suresh2 (Jul-Aug. 2014) [1] This paper based on continuous monitoring underground coal mines parameter such as carbon monoxide, temperature, water level and use wireless Zigbee technology for communication. microcontroller based system is used for collecting and storing data using respective sensors and making decision accordingly, based on which the mine worker is informed through different alarm tone as well as LED display system. The communication system is reliable based on zigbee, IEEE 802.15.4 standard. This is used for transmission between the hardware circuit fitted in the local site (mines) and the remote monitoring site (computer) through routers. This system is highly beneficial for rescue and protection of miners. S.Vandana, V.B.Sundheep [2] In the Era of embedded technology, the Zigbee protocols are used in more and more applications. Because of the rapid development of sensors, microcontrollers, and network technology, a reliable technological condition has been provided for our automatic real-time monitoring of coal mine. The application designs a monitoring system for coal mine safety based on Zigbee wireless sensor network. The underground system collects temperature, humidity and methane values of coal mine through sensor nodes in the mine; it also collects the number of personnel inside the mine with the help of an IR sensor, and then transmits the data to information processing terminal based on ARM. The terminal sends the data to the ground section through Zigbee, and in the ground section, the processing terminal monitors the data and sends the data to the PC to save them and for remote users to inquire .An SMS is also send to the corresponding member through GSM modem which is connected to the controller. If any data is received, the received data is compared with the predefined threshold values, if the received values are more than the threshold values then buzzer will be on. So that

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warning to the personnel occurs. Wu Li Song1, and Jing Qiao (2015) [3] In order to ensure the safety in production, it is necessary to build a wireless communication system that does not rely on a wire backbone. With the development of wireless sensor network, this kind of monitoring system has been true. With the emergence and development of agent, the idea distributed sensor network based on agent has been raised, and the methods of performing collaborative task between many sensor nodes have been developed. It has reduced the requirement of bandwidth and the energy expenditure of network, thereby increasing the life of WSN. With the rapid development of sensor technology, embedded computing technology, communication technology and semiconductor and microelectronics system manufacturing technology, micro sensor with sensing and computing communication capabilities of the store began to appear in the military, industrial, agricultural and aerospace fields. Wireless sensor networks is set the sensor actuator, a controller and a communication device into integration, resource constrained embedded devices in sensing and driving control ability, computing ability, communication ability in a body. Wireless sensor network is composed of these micro sensor can be real-time monitoring, sensing and collecting network of regional distribution. A variety of monitoring object information, and the information is processed, transmitted to the users who need the information. In recent years, a large number of coal mine production safety in academic and high-tech results continue to emerge, greatly improve the safety production level of coal mine. Coal mine safety monitoring system in cable. Play a decisive role in safety production of coal mine, however, because the cable monitoring system its own limitation and the complexity of coal mine, some environmental parameters under mine, such as methane, dust, carbon monoxide, negative pressure, temperature, wind speed can effectively obtain monitoring, causing great security risks[2]. If we combine the wireless monitoring system based on wired monitoring of existing systems, which effectively make up for the lack of existing monitoring system, improve the coal mine safety production level of great**.** Yu Zhang, Wei Yang, Dongsheng Han and Young-Il Kim (2014) [4]. Environment monitoring is important for the safety of underground coal mine production, and it is also an important application of Wireless Sensor Networks (WSNs). We put forward an integrated environment monitoring system for underground coal mine, which uses the existing Cable Monitoring System (CMS) as the main body and the WSN with multi-parameter monitoring as the supplementary technique. As CMS techniques are mature, this paper mainly focuses on the WSN and the interconnection between the WSN and the CMS. In order to implement the WSN for underground coal mines, two work modes are designed: periodic inspection and interrupt service; the relevant supporting technologies, such as routing mechanism, collision avoidance, data aggregation, interconnection with the CMS, *etc*., are proposed and analyzed. As WSN nodes are limited in energy supply, calculation and processing power, an integrated network management scheme is designed in four aspects, *i.e.*, topology management, location management energy management and fault management. Experiments were carried out both in a laboratory and in a real underground coal mine. The test results indicate that the proposed integrated environment monitoring system for underground coal mines is feasible and all designs performed well as expected. Prof.S.jaynathu,Guntha Karthik, G.Manekar, [5] Slope stability is one of the leading problems faced by opencast mines. The conventional geotechnical sensors are generally monitored by technicians in the field and the available wireless monitoring systems like SSR, LiDAR are more expensive. The purpose of this paper is to introduce the effective real-time slope monitoring systems and the application TDR along wireless sensor networks. The wireless Data Transmission System using advanced antennas at respective slope instruments in underground or opencast mines can be used collect data without any physical connections. Wireless sensor networks (WSNs) are well suited to monitor the movement and it consist of sensor nodes which measure physical quantities and transmit the preprocessed measurement results to a base station wirelessly. Developments in information and communications technology (ICT) support the collection, connection and analysis of data through sensing and monitoring of slopes in mines. As a part of Ministry of Mines sponsored paper, the above system is proposed to be implemented for the first time in India in Dongri Buzurg mine of MOIL-Limited. Liwang Zhu, Shaobo Zhang,Chengzhang Zhu (2014) [6] This paper studied the coal mine safety supervision technology systematically, and proposed an overall structure of an integrated safety supervision system with environment supervision, mine equipment monitoring and person / vehicle location management functions. Then, it intensively analyzed the functional requirements of the system hardcore - supervision substation; and carried out the HW&SW design and development of the supervision substation device which includes CAN bus interface, ZigBee coordinator and various function modules. Finally, by building up a simulation test environment, the performance of the system structure and main functions of the substation device were validated. Moridi Mohammad Ali , Kawamura Youhei , Sharifzadeh Mostafa, Chanda Emmanuel Knox b, Wagner Markus , Jang Hyongdoo , Okawa Hirokazu (2015) [7] An automated underground mine monitoring and communication system based on the integration of new technologies is introduced to promote safety and health, operational management and cost-effectiveness. The proposed system integration considering Wireless Sensor Network (WSN) assisted Geographic Information System (GIS) enables to monitor and control underground mining applications from surface office. Based on the capabilities of WSNs, ZigBee network is adapted for near real-time monitoring, ventilation system control and emergency communication in underground mine. ZigBee nodes were developed to sense environmental attributes such as temperature,humidity and gases concentration; switching ON and OFF ventilation fans; and texting emergency messages. A trigger action plan for monitored attributes above normal and threshold value limits is programmed in the surface GIS management server. It is designed to turn the auxiliary fans on remotely or automatically in orange condition and sending evacuation messages for underground miners in unsafe (red) condition. Multi-users operation and 3D visualisations are other successful achievements of the proposed system for the underground monitoring and communication. Mohit Kumar, Mohnish Sharma, Rishabh Narayan, Sumit Joshi, Sanjay

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Kumar [8] Nowadays the automation has become a basic need for the industries. Induction Motors are the nerves of many industries. Hence Industrial automation is required for precise and accurate operation. This paper proposes a wireless control and monitoring system for an induction motor based on Zigbee communication protocol for safe and economic data communication in industrial fields where the wired communication is more expensive or impossible due to physical conditions. A module of transducers and sensors monitors the parameters of induction machine and transmit the data through Zigbee Protocol. A microcontroller based system is used for collecting and storing data and accordingly generating control signal to stop or start the induction machine wireless through computer interface developed with Zigbee.

3. Methodology

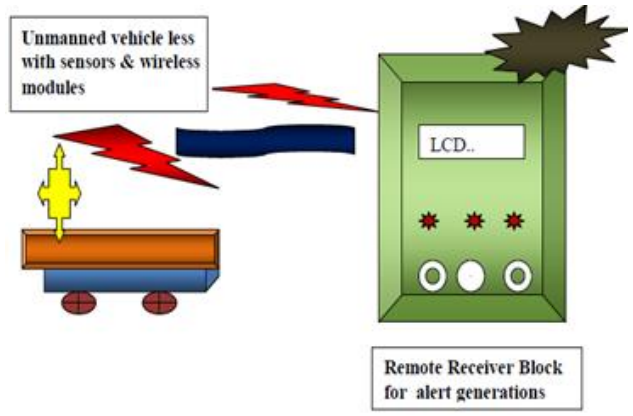

Figure 3.1: Working of WSN framework

In the project of ‗mining safety' we require lot of parameters to measure and to process for the most important function of safety alert generation for actuators. Apart from all these functions human interfacings and data recording also form the part of project. These all functions has to be synchronized and a microcontroller perform all these functions. Microcontroller require in project can be chosen which satisfy all these peripheral and timing requirements. Microcontroller require for this project shall be memory sufficient also with EEPROM capabilities. From the number of available families of microcontroller few may satisfy these criterions and from only those few single chips have to choose. As a part of wireless connectivity options a compatible ZigBee module can be use to transfer sensor data from light system to main remote monitoring systems. Further for light detection LDR's can be use as a sensor & Relays can be use for actuators, also temperature sensor, obstacle sensor & gas sensor can also be attach to project work as per requirement. In this project we describe the development of an IEEE 802.15.4 compatible wireless sensor network (WSN) node for mining & civil safety protocols. The sensor node acquires and internally store data of sensors periodically. Starting times as well as the time intervals for the measurements can be freely programmed over the network system. As soon as an obstacle is detected in its proximity the node will automatically transfer data. Optionally sensor data can be delivered on demand. When in its idle state the node remains in power-down mode in order to minimize power consumption. Secondly attempt can also be make in this work that to generate the alerts as per settable range of unhealthy conditions.

4. Algorithm

Input: Set of n sensor nodes randomly distributed.
Output:One primary and multiple alternate paths from source to sink.

```
repeat
if (node == sinknode) then
FindPrimaryPath();
FindAlternatePath();
else if (node == Primary) then
FindPrimaryPath();
FindAlternatePath();
else if (node == Alternate) then
FindPrimaryPath();
end if
until (node 6= Source)
procedure FindPrimaryPath()
if (node == Primary) then
Broadcast PRIMARY;
Search for the best node;
node ← Primary;
end if
if (node == Alternate) then
Broadcast ALTERNATE;
Search for the best node and prefer Primary;
if (node 6= Primary) then
node ← Alternate;
end if
end if
end procedure
procedure FindAlternatePath()
if node == primary then
Search for the next best path node accept Primary;
if ((node 6= Primary)&&(node 6= Alternate)) then
node ← Alternate;
end if
end if
if (node == Alternate) then
Exit();
end if

end procedure
```

5. Hardware Methodology

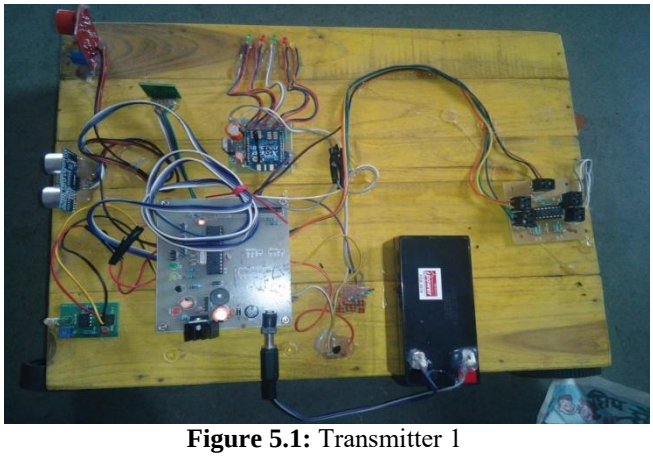

Figure 5.1: Transmitter 1

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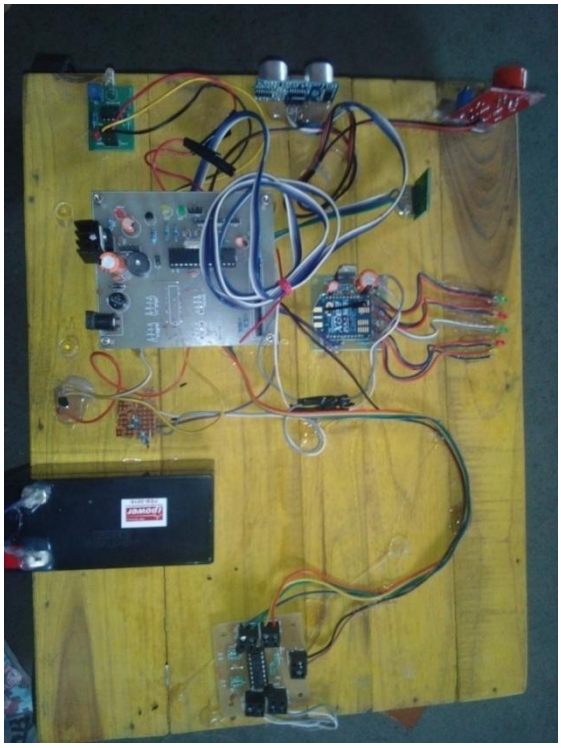

Figure 5.2: Transmitter 2

Figure 5.3: Receiver

6. Result Analysis

Table 6.1: Result

Sr .No.	*Distance ((cm)*	*Temp (^{0}C)*	*Acceleration*	*CHg (ppm)*	*Rst (ms)*
1	0	37	400	145	0
2	3	37	400	145	1
3	3	37	398	144	1
4	6	37	402	146	3
5	12	37	399	145	6
6	15	37	400	145	8
7	18	37	402	146	10
8	18	37	398	144	10
9	21	37	404	146	12
10	24	37	399	145	13
11	27	37	402	146	15
12	33	37	402	146	18
13	42	37	402	146	24
14	60	37	403	146	34
15	75	37	401	145	42
16	78	37	405	147	44
17	81	37	399	145	46
18	84	37	400	145	48
19	87	37	401	145	49
20	90	37	404	146	51
21	96	37	403	146	54
22	99	37	403	146	56
23	102	37	402	146	58

Graphs

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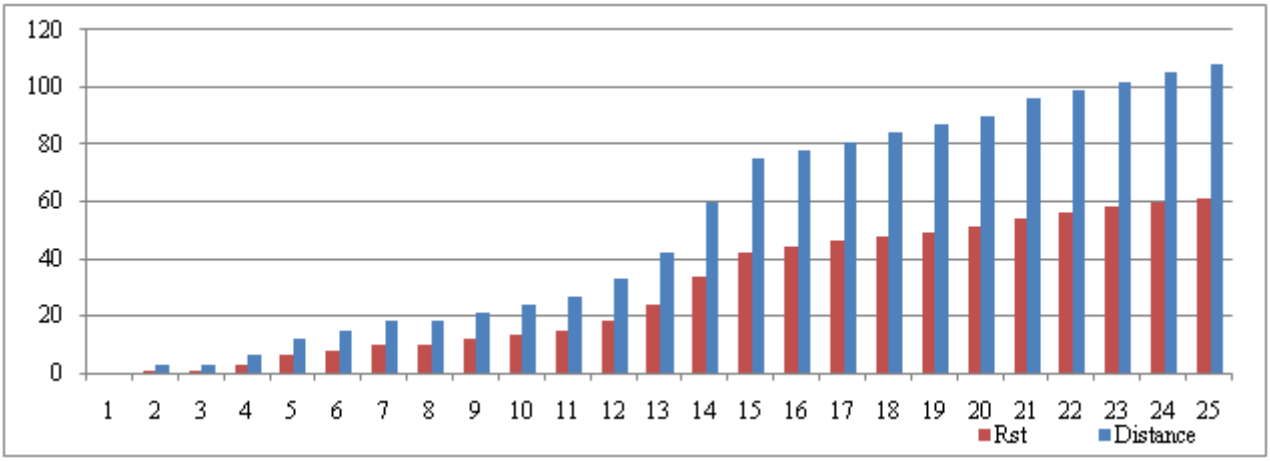

Figure 6.1: Graph for Result

Table 6.2: Result

Distance (cm)	Temp (° C)	Acceleration	CHg (ppm)	Rst (ms)
0	34	275	100	0
3	34	275	100	1
6	34	275	100	3
12	34	275	100	6
84	34	275	100	48
90	34	275	100	51
93	34	275	100	53
96	34	275	100	54
99	34	273	99	56
102	34	274	99	56
105	34	275	100	58
117	34	275	100	59
114	34	275	100	63
117	34	274	99	63
120	34	275	100	63
123	34	275	100	63
126	34	274	99	63
129	34	275	100	63
132	34	275	100	63
135	34	275	100	63
138	34	275	100	63
141	34	275	100	63
144	34	275	100	63
147	34	275	100	63
150	34	275	100	63
153	34	275	100	63
156	34	275	100	63
159	34	275	100	63
162	34	275	100	63
165	34	275	100	63
168	34	275	100	63
171	34	275	100	63
174	34	275	100	63
177	34	275	100	63
180	34	275	100	63
183	34	275	100	63
186	34	275	100	63
189	34	275	100	63
192	34	275	100	63
195	34	275	100	63
198	34	275	100	63
201	34	275	100	63
204	34	275	100	63
207	34	275	100	63
210	34	275	100	63

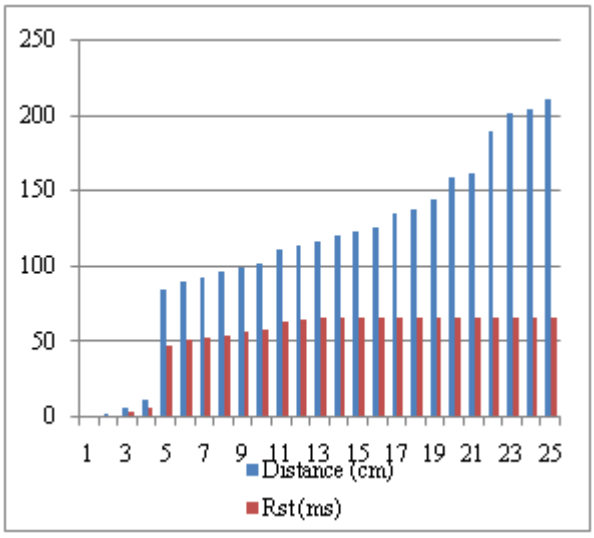

Figure 6.2: Graph

6.1 Conclusion

Wireless has a lot to offer wireless fault transfer for mining/civil applications because of low cost deployment and redeployment, mesh networking to cover entire industrial plants and factories, open standard with multiple vendors, battery operation. As we are implementing this project for display & all necessary data transfers, this project form the wide scope to utilize wireless for improved control & operations. With the development of different gateways this project can be further used for forming the different web servers & can be employed to DBMS. Previously designed systems uses, sensors on helmets or on the wrist of the workers. But we are using unmanned vehicle, it will be possible to have alert generation before any hazard. And it will be effectively useful for fault data transfer**.**

6.2 Future Scope

1) Automatic mining real time sensor data tracking & mapping.
2) Position based switching & operating.
3) Remote alarming & alerting.
4) Maintenance info mobility systems without external network dependency.
5) GUI application developments for database developments & managements if required.
6) With amphibians' robo technology, system can further be utilized for under water hazard detections.

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