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COMMUNICATION TO WIRELESS SENSOR NETWORK IN UNDERGROUND MINES USING Li-Fi

[1]B.Sabarish Rajan, [2]K.Mohanraj, [3]D.Deepak, [4]M.Sudhakaran
[1,2]Dept of EEE, GTEC Engg. College, Vellore,
[3]Asst. Prof, Dept of EEE, GTEC Engg. College, Vellore,
[4]Associate Prof, Dept of EEE, GTEC Engg. College, Vellore.

Abstract:
Wireless Sensor Network (WSN) used under the coalmine tunnel is an emerging area of research that promises to provide reliable and flexible communication. This paper first discussed the best working frequency about the WSN in coalmine. Then, according to the actual circumstances of coal mine, the network structure should adopt cluster-tree topology. We also develop a multifunction communication wireless system using ZigBee and Wi-Fi technology, which can achieve the functions of gas monitoring, wireless communication, personnel management and video surveillance, etc. Practical applications showed that the multifunction communication system can satisfy the need of dispatch communication and safety monitor in the coal mine tunnel.

Keywords- ZigBee; Wi-Fi; Communication system; Coalmine tunnel.

1. INTRODUCTION

At present, the situation of safe production is very serious in Chinese coal mine. Especially in the recent few years, disasters occur frequently in coal mine, which brings huge loss of possession and life. Therefore, the safety of underground mine become an important issue. Management of the hazards in underground mines requires continuous monitoring of critical information: the presence and concentration of flammable and toxic gases and dust, the structural integrity and stability of the mine tunnels, water ingress, and the current locations and communication status of all underground mine personnel. In the aftermath of an accident, it can be vital to maintain communications with trapped miners and rescuers, and to establish and track their positions. Current monitoring system in underground mine were cable based which play a key role in safe production. However, these systems have some disadvantages for coal mine monitoring. It is inconvenient to dispose in many areas such as abandoned laneway and exploiting areas for the trouble reconnection. But just in these areas, they really have a lot of danger. To overcome shortcomings of wired systems, people proposed the Wireless Sensor Networks (WSN) to implement the wired monitoring system. But the WSN has its own limitations, such as not having enough bands to communicate and transfer image data efficiently. So, how to overcome the limitations and provide one communication system with wide band is concerned. The remainder of the article is arranged as follows. The next section we discuss the choice of working frequency for the wireless systems and the node deployment. Then, we introduce the wireless system that we invent using ZigBee and Wi-Fi technology which can satisfy the requirement of coalmine need.

2. FREQUENCY CHOICE

The IEEE802.15.4 PHY has been designed for three bands as 868MHz, 915MHz and 2.4GHz [7]. Although above the ground, the 868MHz band is used in Europe, the 915MHz band in North America, Australia, etc., and the 2.4GHz band has been accepted in almost all the countries of the world. When the WSN is used in underground coal mine, it may not comply with the regulation. So choose the appropriate working frequency is worth concerned. The shape of the coal mine tunnel is generally rectangular, arch or

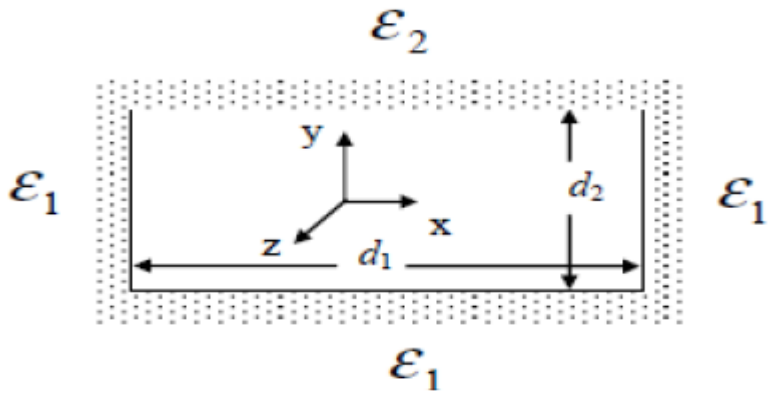

Fig.1. Rectangular tunnel model

trapezoid. Through the theoretical analysis and experiment, it shows that the tunnel section area has great affect on the radio propagation, while the shape of cross section has little [8]. For convenient discussion, rectangular tunnel is as an example. The geometry of an electromagnetic wave in a rectangular tunnel is showed in figure 1. The coordinate system is centered in the tunnel with x horizontal, y vertical, and z along the tunnel.

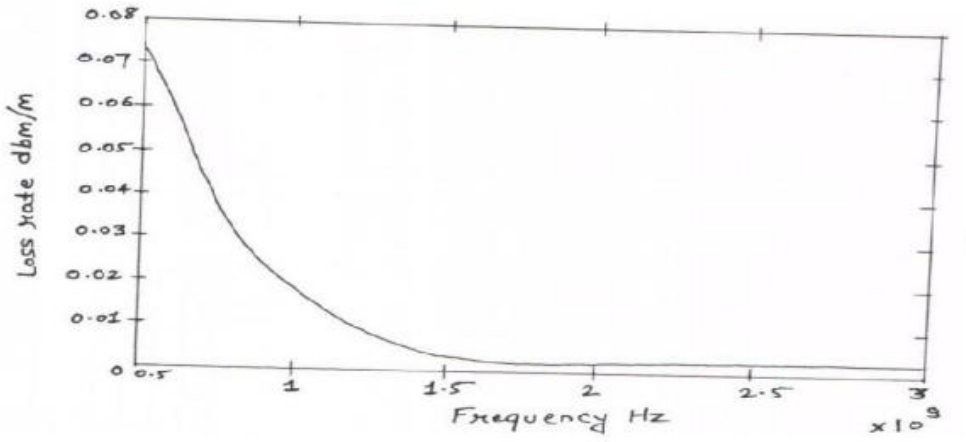

Fig.2. Relationship between attenuation and frequency in rectangular tunnel

The width of the tunnel is d1 and the height is d2. The propagation modes with the lowest attenuation rates in a rectangular tunnel in a dielectric medium are the low(1,1) modes, which have the electric field (E) polarized predominantly in the horizontal and vertical directions, respectively. We refer to these two modes as h E and v E modes. As the propagation attenuation in the tunnel is dominated by the (1,1) h E mode[9], we only consider the attenuation of the (1,1) h E mode. Considering the actual size of the coal mine tunnel, we take: d1 =4m, d2 =3m, and also considering the effect of moist in the tunnel, we take: ε1 =2, ε2 =6. The curve of the calculated attenuation changing with frequency is showed in figure 2. From the figure, we can see that with the increase in communication frequency, the attenuation decreases continuously.

3. NODE COVERAGE

Test under the coal mine shows that when the RF transmitting power is 100mW (maximal transmitting power of 2.4GHz set by the state), it can cover 100–150 m by using omni-directional antenna. But if using directional antenna, the cover range's radius can reach 300m in the straight main tunnel. IEEE 802.15.4

specifies that each device shall be capable of transmitting at least 1 mW [7]. Typical devices (1mW) are expected to cover a 10–20 m range. As radio propagation along the coalmine tunnel has a strong waveguide effect, we can confirm that the cover range is at least 10-100 m in the coalmine tunnel. A ZigBee device can be divided to a full-function device (FFD) or reduced function device (RFD). A ZigBee network shall include at least one FFD, operating as the personal area network (PAN) coordinator. An

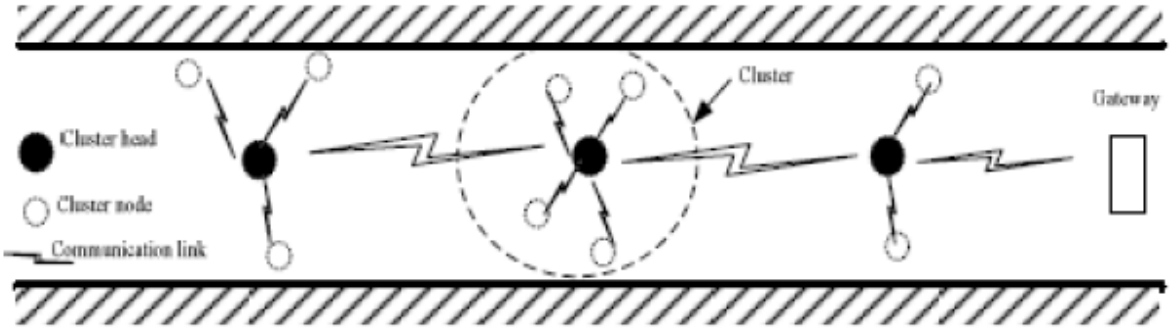

Fig.3. Topology of cluster-tree in coalmine tunnel

FFD can talk to RFDs or FFDs, while an RFD can only talk to an FFD. While in the coalmine tunnel, the monitor devices are only put in the places that need monitor, so the ZigBee nodes are not need to full occupy in the coalmine tunnel. We can adjust the RF power of FFD and RFD to make the different transmitting range and form the topology of cluster-tree as shown in figure 4. Each cluster is composed by cluster head (CH) and the cluster nodes (CN). CH is as Full function device (FFD) which can become the network coordinator, while CN is as reduced function device (RFD) which can only function as a network device. In Figure 4, the CH nodes are deployed to chain-type for the length much larger than the width of tunnel.

4. RESULT ANALYSIS

Aiming at solving the limitation of ZigBee technology using in the coalmine tunnel, under the support of ministry of information industry development fund and national science and technology support program project, we have successfully invented a set of multifunction wireless system using ZigBee and WiFi technology that can achieve the functions of gas monitoring, wireless communication, personnel management, video surveillance and strong antidisaster, etc. The system consists of two parts: under the ground and above the ground. Under the ground mainly consists of base station (BS), wireless sensor,

Fg.4. Base station installation on site

dual-mode mobile phone, identity card (ID card), video camera, etc. all these devices must be intrinsic safe or explosion-proof. The devices on the ground mainly in the monitor room, they include console and varies servers. Figure 5 gives the monitor image that can be seen in the monitor room. To satisfy the different band need, it uses ZigBee/IEEE 802.15.4 and IEEE 802.11 b/g (WiFi) protocols. Any equipment use these two protocols can connect to the base station. In our system, dual-mode mobile phone and video camera connect to the BS use WiFi technology, while wireless sensor and ID card use ZigBee technology. When using ZigBee technology, the BS is FFD and CH, and the sensors and ID cards are RFD and CN. The sensor and ID card only send signals to the BS and the BS read these data by poll method. Two BSs are connected by the optical cables. The BS's power was supplied by the underground grid. The base station also has backup power that can sustain more than 2 hours. The sensor and ID card use battery.

CONCLUSON

This paper studied the wireless sensor network used in the coalmine tunnel. Through our study, we get that the working frequency should adopt 2.4GHz and the network structure should adopt cluster-tree topology in the coalmine tunnel. The multifunction wireless system that we designed has been used in several coal mines. The user's feedback shows that this system has achieved our expected purpose and gets a good economic benefit.

REFERENCES

[1] Pra,sant Misra, Salil Kanhere, "Safety Assurance and Rescue Communication Systems in High-Stress Environments: A Mining Case Study," IEEE Communications Magazine, 2010, 4: 66-73.

[2] M. Li and Y. Liu, "Underground Coal Mine Monitoring with Wireless Sensor Networks," ACM Trans. Sensor Net, 2009, 5: 1-29.

[3] A. Chehri, P. Fortier, and P. M. Tardif, "UWB-Based Sensor Networks for Localization in Mining Environments," Ad Hoc Network, 2009, 7: 987-1000.

[4] Z. Xuhui and W. Sunan, "Design of a Wireless Sensor Network for Methane Monitoring System," 6th IEEE Int'l. Conf. Industrial Informatics, 2008. 614-618.

[5] R. Mangharam, A. Rowe, and R. Rajkumar, "Firefly: A Cross-Layer Platform for Real-Time Embedded Wireless Networks," Real- Time System, 2007, 37:183-231.

[6] X. D. Wang, X. G. Zhao, Z. Z. Liang, and M. Tian, "Deploying a wireless sensor network on the coal mines," Proceedings of the IEEE International Conference on Networking, Sensing and Control. London. UK, 2007. 324-328.

[7] IEEE standards 802.15.4, 2006.

[8] Sun Jiping, Cheng Lingfei, Zhang Changsen, "Influence of transverse dimensions on electromagnetic waves propagation in rectangular tunnels," Journal of China University of Mining &Technology, 2007,34:596-599.(in Chinese).

[9] A.G. Emslie, R.L. Lagace, and P.F. Strong, "Theory of the propagation of UHF radio waves in coal mine tunnels", IEEE Transactions Antennas Propagations, 1975, 23:192–205.

[10] LK Bandyopadhyay, SK Chaulya, PK Mishra, "Wireless Communication in Underground Mines: RFID-based Sensor Networking," Springer: New York, 2009.