International Journal of Recent Engineering Research and Development (IJRERD)
ISSN: 2455-8761
www.ijrerd.com || Volume 02 – Issue 07 || July 2017 || PP. 97-101

Design and Development of Coal Mine Safety System using IoT

Aravindu.S[1], Athreya.M[2], Aqshay.C[3], Karthikeyan.J[4], Priya.B[5]
[1,2,3,4]UG Students, [5]Associate Professor
Rajalakshmi Engineering College, Chennai

Abstract: Recently, the coal mine safety accidents have caused serious casualties and huge economic losses. Hence, it is necessity for the global mining industry to increase operational efficiency and to improve overall mining safety. This paper proposes a middleware to achieve remote monitoring and control automation of underground physical sensor devices used in mines. To implement this an Open Service Gateway initiative (OSGi)-based uniform devices are used in wireless sensor network. To evaluate the performance of proposed system a prototype model is developed and the results are analysed.
Index Terms: Coal mine safety, Control automation, IoT, WSN.

I. Introduction

Underground mines are usually extensive labyrinths, of which the tunnels are generally long and narrow with a few kilometers in length and a few meters in width. Thousands of mining personnel are needed to work under extreme conditions according to the construction requirements, and hundreds of miners die from mining accidents every year [1]–[3]. It is now widely approved that the underground mining operations are of high risk. In this view, a monitoring and control system needs to be deployed as one important infrastructure in order to ensure the mining safety and coordinate various tasks. However, underground coal mines mainly consist of random passages and branch tunnels, and this disorganized structure makes it very difficult to deploy any networking skeleton. In such a case, the utilization of a wireless sensor network (WSN) and other sensing devices may have special advantages for realizing the automation of underground monitoring and control due to the rapid and flexible deployment. In addition, the multihop transmitting method can well adapt to the tunnel structure and thus provide enough scalability for the construction of a mining system, and it is very suitable to the comprehensive monitoring and controlling coalmines, which can effectively compensate the deficiencies of the exiting underground cable monitoring system [4]–[7]. Traditionally, coal mine safety monitoring and automation systems were typically designed to meet the requirements of a single monitoring application. The coal mine application has already gone beyond the interconnection of a few large back-end systems, and more and more underground physical devices make the state of objects and their surroundings seamlessly accessible to software systems .As a matter of fact , most works are based on monolithic system architectures, which are brittle and difficult to adapt. A necessary step towards coal mine monitoring and control automation is to provide timely and fine-grained comprehensive alarming information and corresponding disposal process .It is necessary so that it allows the users to identify the levels for coal mine safety alarming, and possibly to adjust monitoring and control rules to ensure the coal mine safety. Furthermore, the user can also control the physical devices remotely via the Web. Currently available coal mine safety monitoring and control systems that focus on the real-time information collection are useful ,but cannot meet the user needs fully with a very high usage obstacle and often requires a complex operation definition and configuration for monitoring and control automation applications, and cannot meet the demand for ad-hoc services by the end users . Recently, in the area of comprehensive application integration, some works have introduced the use of "mashup " concepts [8]–[14], also known as user-generated comprehensive applications. However, they mainly focus on mashing up information services and do not address the requirements that come with physical devices integration. The middleware for coalmine monitoring and control automation needs to rapidly coordinate interaction between the business processes and distributed ,multisource sensory devices Also , the middleware for coal mine monitoring and control automation should change dynamically in are all-time way confronting with continuously and constantly changing for the underground coal mine physical world .With the help of visualization technology, the graphical user interface of different underground physical sensor devices could be created, which allows the sensors to combine with other resources easily.

II. Related Works

The coal mine monitoring and control system can be classified into four categories: database oriented, message oriented, service oriented, and REST-based approaches.

1. Database Oriented Approach Data base oriented coal mine safety monitoring system which is a Structured Query Language (SQL)-based approach , to query underground coal mine sensors and other devices in a simple declarative style from the application layer. Thus, this is not the useful and essence of the all collected sensory data, and the device-specific data filtering and feature extraction is essential Since this method is focused to collect the data from the network ,and the data processing technology is needed in the network and the sensor nodes to reduce the amount of data and energy consumption.

Hence, a large number of safety monitoring data are generated and processed in the process of coal production .It is also important for safety production in coal mines by analysis of massive of historical safety monitoring data with SQL-based approach to achieve forecast of the safety of coal mines.

2. Message Oriented Approach Message oriented coalmine safety monitoring system, allows underground sensor devices to communicate with each other regardless of the underlying hardware. This approach masks the underlying network interfaces from the application layer, allowing the user to focus on application development, which provides an asynchronous communication mode .In most cases, the coal mine safety monitoring and control applications are event-driven, and have more advantages on the traditional request-response models .This approach operates as an asynchronous message, and event-driven communication paradigm that supports many-to-many interactions. Furthermore, advanced message oriented approach adopts publish/subscribe patterns, in other words, the published messages could be defined regardless of the number of subscribers, and consumers subscribe their topic of interests in events that they would like to receive. Therefore, a message oriented approach allows for a loosely coupled relation between publishers and subscribers while greatly enhancing scalability and heterogeneity support.

3. Service Oriented Approach Service-oriented architecture (SOA) makes the role of current industrial organizations more strategic as they establish high-level interoperability among the different components across the domain, which also provides the solutions for systems integration where the functionalities are encapsulated as interoperable services. In our early works presented a novel approach to integrate wireless sensor network into SOA environments using event-driven SOA technologies to develop a closed-loop coal mine safety alarming disposal process, and BPEL is used to define the coal mine safety alarming disposal process. Real-time coal miner localization and tracking system is also proposed in, which includes real-time coalminer dynamic display, 3D Geographic Information System (GIS) user interface, alarming, querying trajectories of all miners, and emergency rescue supporting.

4. Representational State Transfer (REST) Based Approach REST is a series of guidelines to meet the Web standards presented in a distributed architecture software style. RESTful APIs do not require XML-based Web service protocols (SOAP and WSDL) to support their interfaces .In our early study, a wireless sensor network was combined with the controller are a network (CAN) bus technology for the comprehensive and timely monitoring and intelligent early warning in the underground environment, the production data, and the operating status of the equipment, and also design the RESTful API interface for monitoring and control for underground sensor network. All types of parameters were collected and transmitted to the remote monitor center for analysis to provide decision making information for clients.

III. Proposed System

Traditional coal mine monitoring systems tend to be wired network systems, which play an important role in coal mine safety system. Due to this there are possibilities of wires getting damaged , also they require very high energy. The current sensor values at the mine is not accessible to everybody. This system controls the ventilation demand to mine workers depending upon present climate conditions within the mine field.

Here we propose a design of a wireless sensor network (WSN) with the help of Raspberry pi controller which is able to monitor and control the underground mine climate condition. The Internet of Things is regarded as the third wave of information technology after Internet and mobile communication network, which is characterized by more thorough sense and measure, more comprehensive interoperability and intelligence.

SMS Notification – People working offshore get the temperature, humidity and other sensor values without having to go onsite.

High Security- Unauthorised personnel cannot have access to the system without password
The latest Raspberry Pi makes use of an advanced chipset from Broadcom along with an upgraded power system.

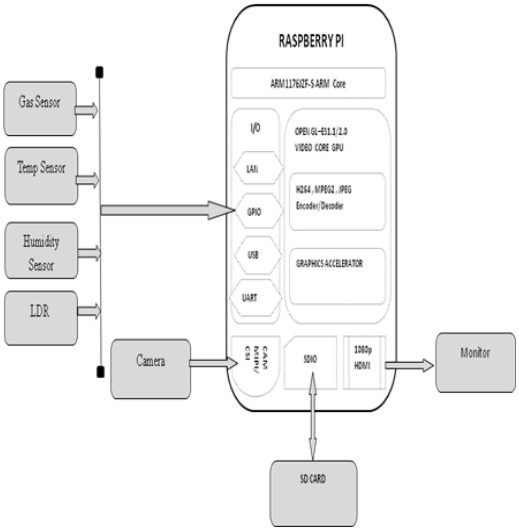

Fig1. Block Diagram

This model has a built in WiFi module which makes the connectivity hassle free. This model also has a 64 bit processor improving the performances largely when compared to other competitive processors.

IV. Results

Based on the proposed system we have devised a protocol model. Our system will alert you with mail and SMS if there is some imbalance in the parameters in the mine and the authorised person will have a control towards the equipments in the mine. so through a web server that we have created he can control the equipment inside the mine from anywhere.

When the light is low inside the mine the LDR sensor detects the lighting in that area and notify with a mail and SMS.

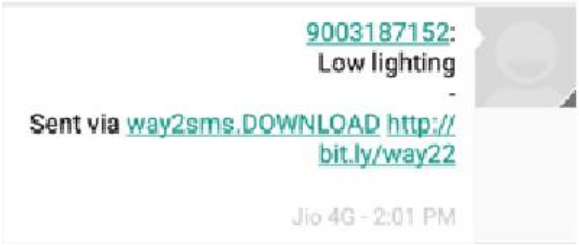

Fig2. SMS notification received when there is low lighting in the mine

In order to measure the moisture content in the mine we have used a humidity sensor. The humidity sensor sense the current moisture content in the mine and we have also used a comparator circuit. A threshold value has been feed into the comparator circuit. The main purpose of the comparator circuit is to compare the threshold value and the current value. If the current value exceeds the threshold value this system will notify with a mail and SMS .

Fig3. SMS notification received when the moisture is high in the mine

Temperature is the main parameter in a mine which must be always in control. So in order to detect the temperature we have used an temperature sensor. The temperature sensor sense the current temperature in the mine and we have also used a comparator circuit. A threshold value has been feed into the comparator circuit.

The main purpose of the comparator circuit is to compare the threshold value and the current value. If the current temperature value exceeds the threshold temperature value this system will notify with a mail and SMS.

Fig4. SMS notification received when the temperature is high in the mine

We have also used a gas sensor to detect the harmful gases. We have also used a camera to capture the current scenario inside the mine and the captured image will be sent along with the mail. The web server we have created helps to control the equipments and machines inside the mines and only authorised person can have access to those web server.

V. Conclusion

This paper builds a middleware for coalmine safety remote monitoring and control visualization. Focus on the design and implementation for underground wireless sensor network deployment, uniform devices access framework, distributed data distribution service, event-driven service execution engine, and RESTful-based open API interface. The main novelty of this study is to develop a middleware for coal mine monitoring and control middleware which is easy to use and install for engineers. Since most of the application is Web-based, any personal computer and a web browser can connect the Internet and enter the Web page to use the application, and which can reduce the costs of coal mine safety monitoring and control automation. Therefore, it is expected to be a main contribution to coal mines for better and safer working environments. Several issues remain to be addressed further. First, as the expansion of existing coal mine safety monitoring and control system, visualization technology can further improve the visibility of underground sensor objects, such as 3D technology, which provides significant support for decision making and real-time control in underground mines. Second, it is essential to optimize the real-time data distribution service and data congest scheduling strategy with different QoS constraints for a large-scale coal mine deployment. These works are currently in progress in our lab.

References

[1]. K. Page, "Blood on the coal: The effect of organizational size and differentiation on coal mine accidents," *J. Safety Res.*, vol. 40, no. 2, pp. 85–95, 2009.

[2]. L. Mallet, C. Vaught, and M. J. Brnich Jr., "Sociotechnical communication in an underground mine fire: A study of warning messages during an emergency evacuation," *Safety Sci.*, vol. 16, no. 5, pp. 709–728, 1993.

[3]. M. Ndoh and G. Y. Delisle, "Underground mines wireless propagation modeling," in *Proc. 60th IEEE Veh. Technol. Conf.*, 2004, vol. 5, pp. 3584–3588.

[4]. J. Wood, J. Dykes, A. Slingsby, and K. Clarke, "Interactive visual exploration of a large spatio-temporal dataset: Reflections on a geovisualization mashup," *IEEE Trans. Vis. Comput. Graph.*, vol. 13, no. 6, pp. 1176–1183, Nov.–Dec. 2007.

[5]. X.-G. Niu, X.-H. Huang, Z. Zhao, Y.-H. Zhang, C.-C. Huang, and L.Cui, "The design and evaluation of a wireless sensor network for mine safety monitoring," in *Proc. IEEE GLOBECOM*, 2007, pp. 1230–1236.

[6]. M. Li and Y.-H. Liu, "Underground coal mine monitoring with wireless sensor networks," *ACM Trans. Sens. Netw.*, vol. 5, no. 2, pp. 1–29, 2009.

[7]. G.-Z. Chen, Z.-C. Zhu, G.-B. Zhou, C.-F. Shen, and Y.-J. Sun, "Strategy of deploying sensor nodes in the chain wireless sensor network for underground mine," *J. China Univ. Mining Technol.*, vol. 18, no. 4, pp. 561–566, 2008.

[8]. A. Bouguettaya, S. Nepal, W. Sherchan, X. Zhou, J. Wu, S.-P. Chen, D.-X. Liu, L. Li, H. B. Wang, and X.-M. Liu, "End-to-end service support for mashups," *IEEE Trans. Serv. Comput.*, vol. 3, no. 3, pp. 250–263, Jul.–Sep. 2010.

[9]. R. Tuchinda, C.-A. Knoblock, and P. Szekely, "Building mashups by example tuchinda," *ACM Trans. Web*, vol. 5, no. 3, pp. 1–45, 2011.

[10]. Z. Yang, F. Yushun, H. Keman, T. Wei, and Z. Jia, "Time-aware service recommendation for mashup creation in an evolving service ecosystem," in *Proc. IEEE Int. Conf. Web Serv. (ICWS)*, 2014, pp. 25–32.

[11]. D. Benslimane, S. Dustdar, and A. Sheth, "Services mashups: The new generation of web applications," *IEEE Internet Comput.*, vol. 12, no. 5, pp. 13–15, Sep.–Oct. 2008.

[12]. E. Maximilien, A. Ranabahu, and K. Gomadam, "An online platform for web APIs and service mashups," *IEEE Internet Comput.*, vol. 12, no. 5, pp. 32–43, Sep.–Oct. 2008.

[13]. J. Cao, Z. Wen, and T. Wei, "Dynamic control of data streaming and processing in a virtualized environment," *IEEE Trans. Autom. Sci. Eng.*, vol. 9, no. 2, pp. 365–376, Apr. 2012.

[14]. A. Bozzon, M. Brambilla, F. M. Facca, and T. Carughu, "A conceptual modeling approach to business service mashup development," in *Proc. IEEE Int. Conf. Web Serv.*, 2009, pp. 751–758.