WSN Based Coal and Gas Outburst Monitoring System

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ABSTRACT: Wireless sensor networks (WSN) are based on small-scale and low-cost devices and achieve processing, storage, sensing and communication. It can be used in real-time monitoring, sensing, and collection of the physical dimensions of the monitoring system. The layer model of the WSN-based monitoring system for coal and gas outburst was proposed after evaluating the current problems of monitoring technology on coal and gas outbursts. The emphasis was placed on sensor nodes and nodes at the sink. And the micro-sensor software design was introduced as well. Results from the monitoring experiments show that WSN is ideal for monitoring systems for coal and gas outbursts due to its low environmental effect, large data collection and high precision detection. The new control system, which incorporates health monitoring and measurement systems for WSN and coal mine, compensates for the limitations of conventional monitoring techniques. This is an important measure to monitor the source of dangerous coal and gas outbursts and remove the secret gas accident issue. The study developed the preventing coal and gas explosion technology.

KEYWORDS: coal and gas outburst; WSN; sensor node; information processing.

INTRODUCTION

Most WSNs (Wireless Sensor Networks)[1] have been implemented in specific environments in recent years, such as environmental monitoring network, health care system, and disaster response system, etc. Throughout this research designing of a Guard Light Flasher Unit (GLFU)[2] with residential area Guard Light Control System, using a WSN system. The Guard Light is committed to ensuring the safety of pedestrians and avoiding crimes in suburban areas and off the beaten track.

Over the last 30 years old fashioned GLFUs that do not take advantage of WSN technology have grown. The first GLFUs are manually operated by the protection overseer. Each day the boss turns the GLFUs on and off punctually. More evolved GLFU's are automatically switched on and off. They use Real Time Clock (RTC), Illumination Intensity Meter, or GPS. However, these GLFUs also face many problems, such as the difficulty of detecting a spot civil case and the difficulty of pre-emptive GLFU failure recognize.

There have been numerous attempts to add a number of wireless networking technologies to the flasher device to tackle these problems. Nonetheless, when used in an outdoor setting, including residential areas in city centers, a GLFU designed with the 2.4GHz wireless bandwidth technology continues to entail too many interruptions of contact caused by obstructive factors such as houses, weather conditions, trees or moving items to be commercialized. Nonetheless, wireless technology with a frequency of 2.4GHz is commonly used in real field due to the lack of network infrastructure. There are currently no commercialized Macs or routing protocols that are ideal for outdoor environments[3].

Therefore, through our proposed successful wireless routing protocol technology for residential areas in city centers, and developed a GLFU adopting a short-distance wireless communication of 447MHz bandwidth. Therefore, planned to demonstrate its efficacy by developing and applying the suggested communication protocols to the real world and presenting the data collected from spot testing[4].

India is one of the countries which is vulnerable to the world's most severe coal and gas disaster. In total there are 230 accidents involving coal and gas outbursts from January 2000 to December 2008, and the total number of casualties is 1100. In the current monitoring of coal and gas outbursts is based primarily on the empirical mining data and some coal bed parameters. The operability, timeliness, and accuracy of monitoring cannot meet the mining and safety management requirements. Although the sudden change may appear after blowing or cutting coal, in coal mine the gas emission has some regulation for a given working face. At the high-gas area, the gas emission change may occur before the gas-induced dynamic phenomenon. It represents the current higher stress district and being in unstable state. Based on statistical data from the annual cases that occurred at home and abroad, many phenomena often occur before or during coal and gas outbursts, such as abrupt increases in gas emissions, ups and downs and so on. And so, it is possible to monitor coal and gas outbursts based on gas detection[5].

Wireless Sensor Network consists of a large number of micro-sensor nodes that are installed in a monitored area. The moving sensor nods have intensity characteristics in the capacity for wireless communication and computation. This network is capable of completing TT&C (Telemetry & Command Tracking)[6] and communication for one target. And WSN is a practical way of tracking coal and gas mine outbursts. This paper constructs a modern, WSN-based outburst monitoring program. This will search the sites that are inaccessible to the conventional wire surveillance network and process data online.

Wireless Sensor Network

Wireless sensor networks (WSN), a novel computing class and a new location for information technology, consist of a large number of inexpensive micro-sensor nodes deployed in the monitored area. By perceiving and controlling parameters, integrated sensor nodes can inspect, collect, process and transmit data about perceivable objects within network coverage. These nodes have the measurement, wireless communication, sensor, and control functions. Over the past few years, the WSN has drawn ever more attention in the field of environmental monitoring.

Similar to the conventional control network for coalmines in real time, WSN has several advantages:

(1) Nodes of WSN-based control systems are commonly installed in bad environments (goaf, outburst region and gob caving unit, etc.), where conventional network facilities are difficult to arrange. Sensor nodes can be reconfigured with distribution routing protocol and distributed algorithm, and communication link can be dynamically established.

(2) Sensor nodes can be out of operation at any time due to different causes such as mode of exchange between work and sleep, exhausted power, changed state, moving object of consciousness. Hence, WSN topology structure is liable to continuously shift with disrupted contact of nodes.

(3) Since the sensor nodes are miniaturized, they have very low battery power. Moreover, they are also worked in certain daunting or inaccessible circumstances. Once the system runs out of control, the battery replacement issue comes with it. So sensor nodes use the inter mitten working pattern to reduce energy consumption and lengthen operating time. That means that once nodes receive no orders or data, they can choose to sleep, and function.

ARCHITECTURE DESIGN

The WSN for tracking the coal and gas explosion is made up of sensor nodes, sink nodes and manager nodes. Figure 1 shows the design of a monitoring system architecture. A significant amount of sensor nodes are deployed with the propensity of outburst on the working face, and through self-organization they form the low level network. They are in charge of collecting the gas material. Every node within the network only communicates with its adjacent node. In accordance with the agreement of the related multi-hop configuration, the date-packet sent by each node is sent to sink nodes, arranged in main roadways.

The sink nodes then relay data by wire network to manager nodes on the ground. There the data will be processed and analyzed and then the real-time analysis of the blind field in wire measurement will be carried out. The manager nodes can also submit instructions to low-level underground wireless networks at the same time.

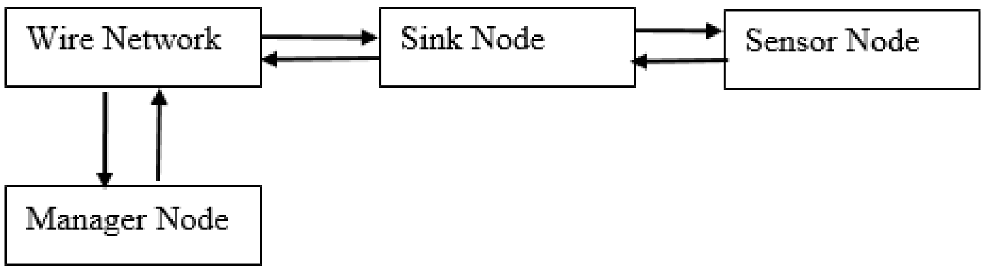

Figure 1: Architecture of Coal and Gas Outburst Monitoring System Based on WSN

HARDWARE DESIGN

A WSN node is more of an embedded micro miniature network. What it transmits to a gateway is not a raw environmental date but the handling of the data required. Sensor nodes should work reliably and effectively to set up a WSN for monitoring the ambient temperature, and designed miniature nodes must have low cost and low power consumption. The sensor node includes a sensor module, a data processing module (memory, controller), a wireless communication module (wireless transceiver), and an energy module (battery or power). Figure 2 shows a sensor node's Hardware design.

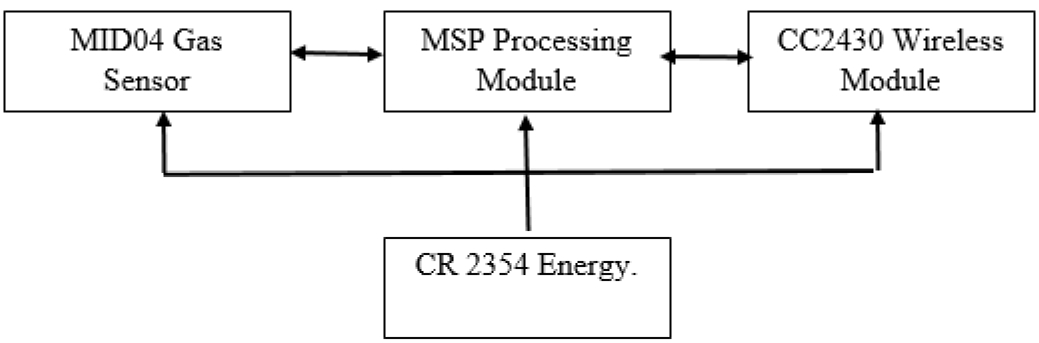

Figure 2: Architecture of a Sensor Node

In the monitoring system, the controller, WSN nodes' "computational engine," takes responsibility for data collection and processing, decides when to send and receive data, and judge’s actuator work. MSP430F149 is used in a kind of ultra-low power consumption processor TI that can work reliably and stably in bad environment. It is a special embedded device applications facing microprocessor chip with 16-bit CPU and high-efficiency RISC[7] device. The instruction time can be as high as 125ns at 8MHz clock rate. The chip is fitted with ample peripheral modules, and has several different methods of sampling and high speed sampling. The CC2430, implemented in the monitoring system, is an IEEE 802.15.4(ZigBee) system-on-chip[8]. The chip can provide an effective and reliable data rate of 250 Kbps with 2.4GHz RF transceiver, enhanced 8051MCU, 128 KB Flash ROM and 8 KB RAM integrated in it. The MID04 Smart Infrared Gas Sensor is used to monitor outbursts. It has the features of wide dynamic detection range, fast response time, high selectivity, etc. The CR2354 micro miniature lithium-ion battery[9] is adopted to meet the requirement of nodes low in volume. The output voltage is 3V, and is 530 mAh.

Software Design of WSN

The software design involves mainly software design for acquisition of signals and software design for data processing. The signal processing program operates on WSN wireless information collection nodes. It is mainly responsible for collecting data and transmitting wirelessly through wireless communication module. If developing applications, the concept of light weight, modularisation and local co-operation should be adhered to. At the same time, the program must ensure very good adaptability in order to adapt to WSN's change in requirement and dynamics.

Sensor nodes have to switch between sleeping mode and awake mode at a low duty cycle due to the restricted power supply to prolong the life of the network. The sensors are on sleep to conserve energy and when there is no received signal, the microprocessors stop operating. And wireless communication module with low current remains embracing state. Upon receiving instructions from sink nodes or neighboring nodes, sensor nodes immediately enter into working and wake up neighboring nodes. Upon completion of the instructions, nodes return to sleep state. Figure 3 shows how the sensor nodes operate.

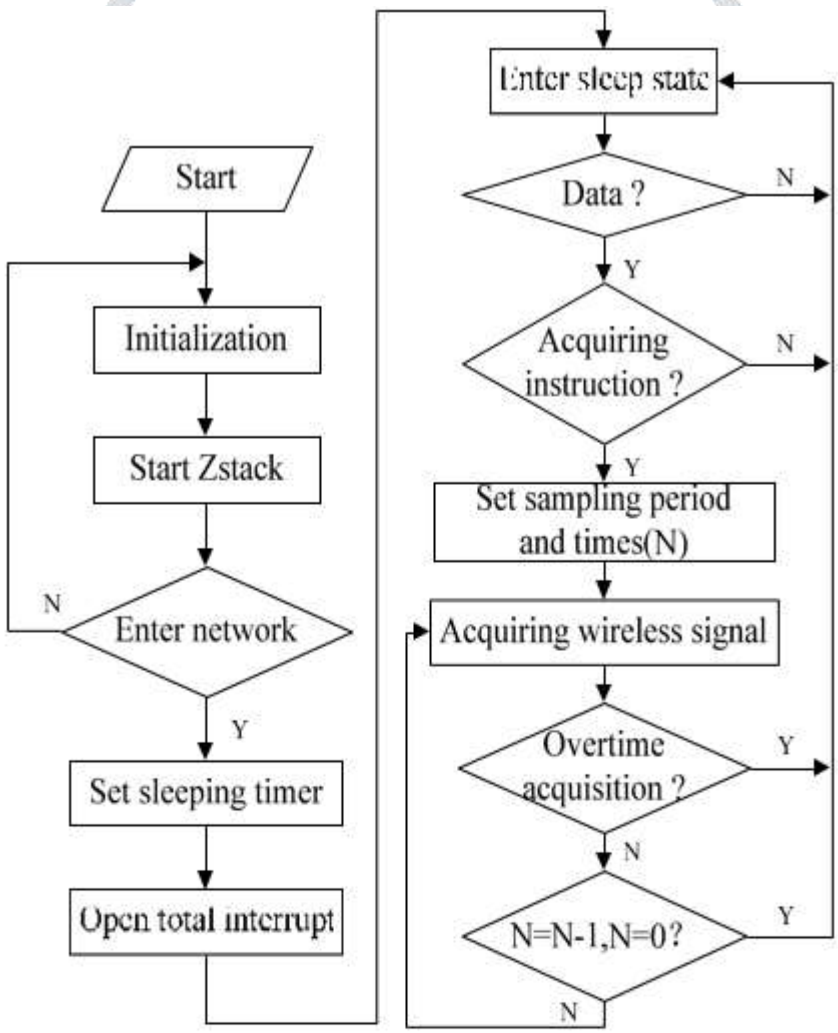

Figure 3: Operation process of the micro-sensor node

The Z Stack protocol stack will operate after node initialization. Once the nodes are efficient in reaching the network, the sleep timer is set and the interruption is opened. Then the nodes reach sleeping state and hold operation low power. When wireless information is tracked it will be processed and identified by the nodes. If the received information is successful, then sensor nodes will wake up and take the collection working pattern. At the Bottom

The sampling length and times (N) are set in the same time frame. Until instead, the device gathers until uploads information on the wireless monitoring process. This process continues until collection times have been established.

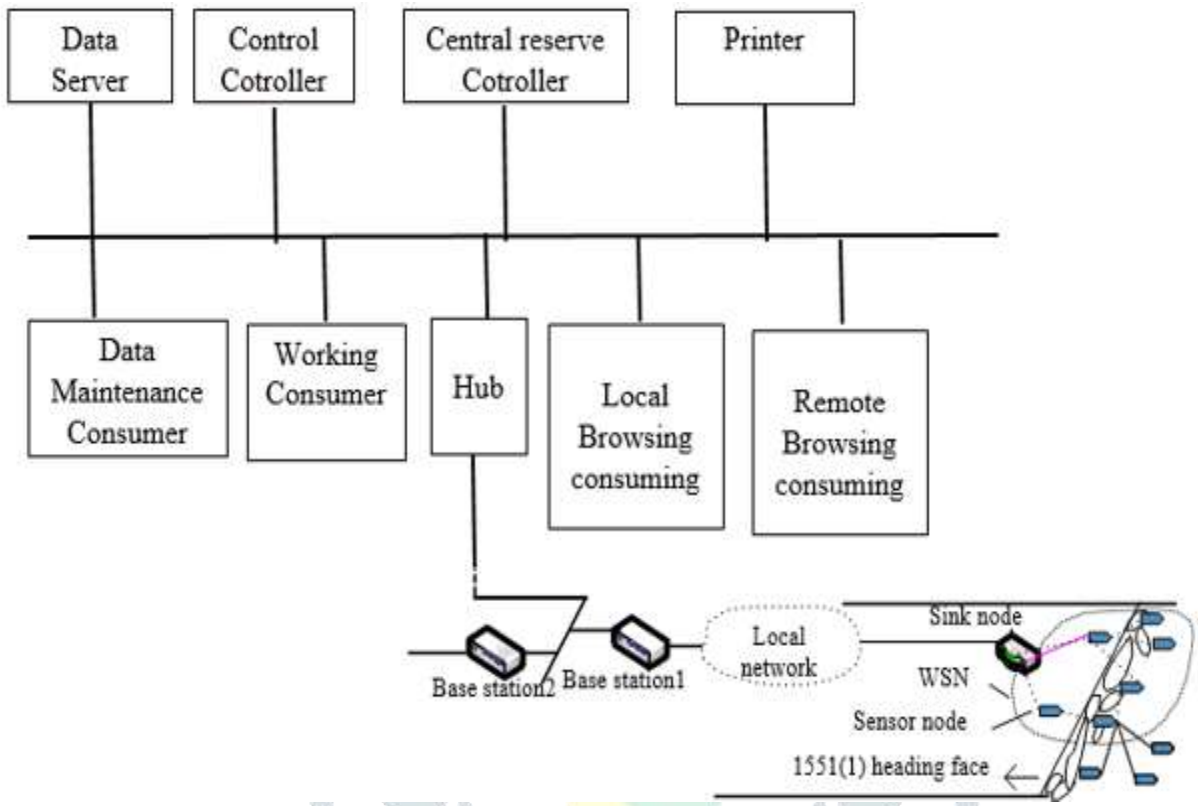

Figure 4: Test of WSN-Based Outburst Monitoring System

The increase in gas emissions is low under normal working conditions and the gas concentration variance curve is flat and stays at 0.04%. The concentration of gas emissions increased suddenly to 0.16%. It was back to normal, after about 30 minutes. The long-lasting irregular change in gas emissions, the constantly rising signal curve pattern and regular fluctuating shifts are all warning details regarding coal and gas outbursts. And the cause has to be identified by study and exploration. Similar solutions for removing secret coal and gas outbursts need to be put forward.

CONCLUSION

A new system for monitoring coal and gas outbursts was put forward on the basis of the presented safety monitoring system based on wireless sensor network. The test results show that the time-series of gas emissions may indicate the characteristic of the complex system of coal and gas. And the condition of coal in the bursting area's working faces can be identified by examining the signal obtained from WSN. The argument is an exception to predictions for coal and gas outbursts. And it will encourage WSN work that is used in tracking the health of coal mining. Lots of work is to be done for the complicated mine environments, such as framework design, system testing.

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