Wireless Sensor Networks based Forest Fire Surveillance System

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Abstract *- Wireless Sensor Networks will revolutionize applications such as environmental monitoring, home automation, and logistics. We developed forest fire surveillance system. In this paper, Considering the fact that in Korea, during November to May, forest fires occur very frequently causing catastrophic damages on the valuable environment, Although exists other forest fire surveillance system such as surveillance camera tower, infrared ray sensor system and satellite system. Preexistence surveillance system can' t real-time surveillance, monitoring, database and automatic alarm. But, forest fire surveillance system(FFSS) support above. In this paper, we describes a system development approach for a wireless sensor network based FFSS that is to be used to measure temperature and humidity as well as being fitted with a smoke detector. Such a device can be used as an early warning fire detection system and real-time surveillance in the area of a bush fire or endangered public infrastructure. Once the system has being development, a mesh network topology will be implemented with the chosen sensor node with the aim of developing a sophisticated mesh network.*

Keywords: Wireless sensor network, Surveillance System, Middleware, MCF

1 Motivation

Wireless sensor networks(WSNs) hold the promise of many new applications. The underlying technology that drives the emergence of sensor applications is the rapid development in the integration of digital circuitry, which will bring us small, cheap, autonomous sensor nodes in the near future. Wireless sensor networks are an emerging technology consisting of small, low-power, and low-cost devices that integrate limited computation, sensing, and radio communication capabilities. This technology has the potential to have enormous impact on many aspects of emergency operations.

Ubiquitous Sensor Network (USN) is expected to be realized over the next ten years. The interest in sensing technology for various uses has been growing, and new kinds of sensors have been developed by micro electro mechanical systems (MEMS) technology. Environmental information, such as temperature, Humidity, sound, vibration, as well as pictures from a certain place in a building, can be evaluated by the ubiquitous sensor network. A number of studies have been conducted on structural health monitoring for buildings and civil engineering structures in recent years [3]. Some of these studies have focused on wireless sensing technology.

Researchers at the Stanford University have developed a wireless sensing unit for real-time structural response measurements and conducted a series of validation tests . In Japan, the Mitsubishi Electric Corporation has developed an energy-saving wireless sensor network. The University of Tokyo and the Oki Electric Industry have devoted their effort to develop new wireless sensor networks. Recently, a commercially available wireless sensor platform called the "MICA" was provided by researchers at the University of California, Berkeley [9], and its application to the next generation of structural health monitoring and control was recently proposed [1, 2]. Because of its open hardware and software platform, the Berkeley Mote is a useful tool for research activities. In this paper, we developed Forest-Fire Surveillance System (FFSS). Figure 1 shows the heat threat of bush fire during the fire seasons in Republic of Korea [8].

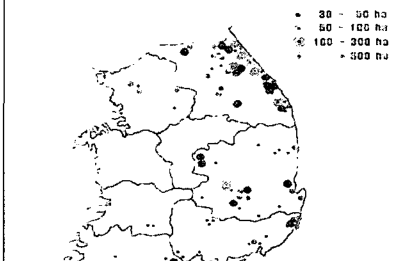

Figure 1. Forest fires during the period 1980-1999

2 Sensor Network platform

2.1 Sensor Network

A wireless sensor network can be connected to the internet so that the information can be used for monitoring future risks. Wireless sensors are easy to install, remove, and replace at any location, and are expected to become increasingly smaller through the use of MEMS technology. They will provide a ubiquitous, networked sensing environment in anywhere. For example, the acceleration and strain at numerous locations on each beam and column, temperature and light in each area, and images and sounds in desired regions can be obtained by the sensor Node sensors, as illustrated in Figure 2. Additionally, a single type of sensor such as a condenser microphone can be used for multiple purposes, for example, to detect earthquake, fires and intrusions [10]. Furthermore, a fiber optic network is not only utilized as infrastructure for information technology, but also as a "wired" sensor network. Table 1 shows hazards, possible applications and combination of sensors. Furthermore, a fiber optic network is not only utilized as infrastructure for information technology, but also as a "wired" sensor network. Table 1 shows hazards, possible applications and combination of sensors.

Table 1. Sensor application area

Hazard	Application	Sensor
Earthquake /Wind	observation	acceleration
	experiment	Acceleration/strain
	Structural control	Acceleration
	Health monitoring	Acceleration/strain/displacement
	Damage detection	Acceleration//strain/displacement
Fire	fire detection	Temperature/smoke/acoustic /olfactory/acceleration
	Gas leak detection	Olfactory
	Alarm, warning	Sounder
	Evacuation control	Temperature/smoke/accustic/light/olfactory
crime	Surveillance	Acceleration/light/acoustic/camera
	Security alert	sounder

2.2 Sensor Node

FFSS used TIP50CM. TIP50CM is system that can utilize various sensor and realize SFN application as device node to compose SFN to use frequency of 2.4GHz band. The technologies for Applications are Sensor network technologies for ubiquitous computing infrastructures, Multi-hop ad hoc network solution, Low power communication technology and intelligent context-aware middleware service. Specifications of Tip50CM view in Figure 2 and Table 2 [4].

Figure 2. TIP50CM

Table 2. Specification of TIP50CM

Item	Description
Processor	16bit RISC, 8MHz
Memory	256KB Program Flash
Operating System	TinyOS
Multi-channel Radio	2.4GHz
Data Rate	250Kbyte
Sensor	Temperature, Humidity and Light
Network	Multi-hop and Ad hoc
Interface	USB(UART)
Size	68×29mm
Power	3.0~3.3V
Range	70m in lab

TinyOS is a distributed, open-source operating system which supports large scale, self-configuring sensor networks as shown in the Figure 3 [5]. The forest-fire surveillance for forest by using the ubiquitous, networked sensing system discussed in Figure 3 requires ad hoc and multi hop, because a long distance communication among large number of sensors in the building is not realistic.

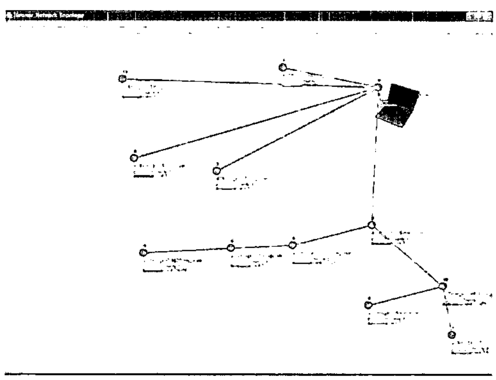

Figure 3. Multi hop routing

2.3 Minimum Cost path Forwarding

In this paper, routing protocol used Minimum Cost path Forwarding (MCF). MCF finds shortest paths from all the sensor nodes to the base station and requires no explicit routing tables to be maintained at each node. Routing all the data along a shortest path might potentially drain all the energy from upstream nodes, thus losing coverage in some regions of the network. In our method, we mitigate this possibility by limiting the amount of energy each node can spend in a round. MCF design has been driven by the following three goals:

- Optimality: Most data forwarding protocols are designed based on a chosen optimality criterion. Our design seeks to achieve minimum cost forwarding. Some popular cost criteria include hop count, energy consumption, and delay etc.

- Simplicity: The cost-effectiveness factor of a sensor network dictates that nodes have limited computing capability and memory resources. We seek to minimize the number of operations performed and the states maintained at each sensor node that participates in data forwarding. In particular, we do not maintain any explicit "forwarding path" states. We do not even need an ID for an intermediate node.

- Scalability: Since unconstrained scale is an inherent feature of a sensor network, the solution has to scale to large network size.

3 Application platform

3.1 WSN and Transceiver

FFSS sense environment state and determine forest-fire risk-level by formula of the Office of Forestry. Then FFSS provide automatic alarm. FFSS show in Figure 5. Wireless sensor network is that is comprised of sensor nodes that sense and communicate temperature, humidity and illumination data. Base-station is one of sensor node on WSN. This node concentrates packet of WSN and forward to transceiver. Transceiver transports packets that received from base-station (Figure 4). When transceiver received packet, it verify packets and then analysis packet for middleware. Packet structure is Table same to as Figure 5.

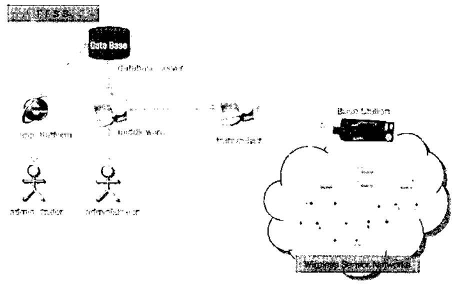

Figure 4. FFSS components structure

$$Y = 6.87 + (0.64 \times P) + (0.15 \times EF) + (1774.94 / CS) \quad (1)$$

EF= practical result humidity (%), CS= addition solar radiation (MJ/m'), P= Rain falling (mm)

Node ID	Parent Id	Hop	Temp	Hum	Illum	Battery

Figure 5. Packet format

Transceiver (Figure 6) is gateway of WSN. Each WSN can connect to outside network through this transceiver. And transceiver work as TCP/IP socket server then middleware can connect with the transceiver and receive parsed packets. Also transceiver display receiving status so that administrator can monitor easily.

3.2 Middleware and Web Application

Middleware (Figure 7) receives packets from transceiver then process packet and display results. The results contain that forest-fire risk-level. This level is calculated by formula defined by the Office of Forestry (formula (1)). Then FFSS can provide automated surveillance system. And more middleware store received packets to database server. Below screen-shot is main window of middleware. Middleware was composed with some component so that Administrator can grasp the situation easily. Component provides statistics viewer about recoded data on database. Administrator can see statistic graph and table. Components provide real time graph about receiving data that containing temperature, humidity, illumination and battery. Administrator can grasp sensor status information. Component is topology viewer. Administrator can grasp WSN logical topology. This view that show present condition of fired sensor nodes.

Web Application (Figure 8) is comprised of web-application and database server. Web application provides that administrator can monitor through internet. Web-application is comprised of web pages and applets. Applets communicate with data-base server and display information. Web-application provides all most of functions of middleware.

4 Conclusions

In this paper, we developed WSN based Forest-Fire Surveillance System. As a result, FFSS observes real-time forest's state of anywhere region. If the forest-fire have been happened, FFSS alarm give previous notice in fire station or neighbor residents. Real-time observation of FFSS can be early extinguishment of a forest-fire so that damage and injuries will be reduced than before. Further research on more effective modes of communication that facilitate no data loss is needed to achieve a wireless sensor network for the others monitoring.

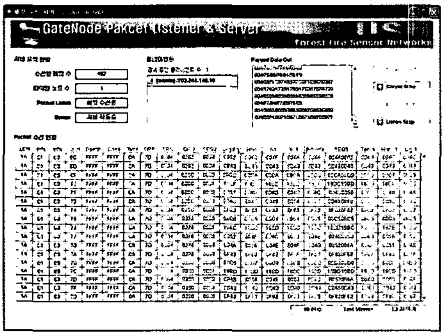

Figure 6. Transiver

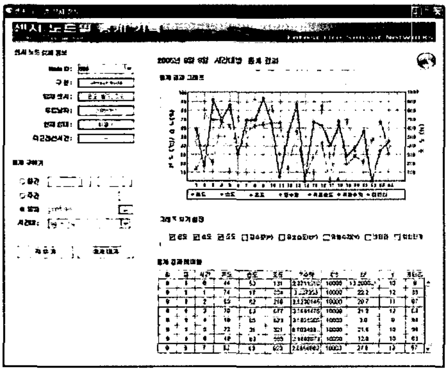

Figure 7. Middleware

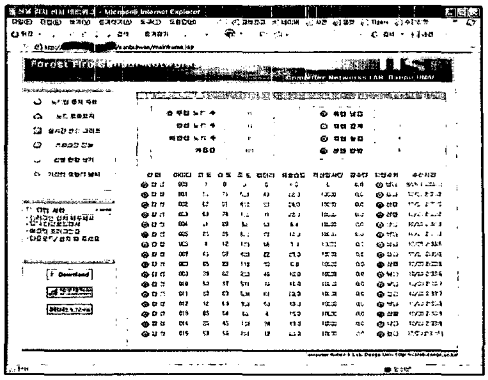

Figure 8. Application platform

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