OFFSHORE PLATFORM HEALTH MONITORING APPLICATIONS OF WIRELESS SENSOR NETWORK

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ABSTRACT

Health Monitoring is very important for large structures like suspension- and cable-stayed bridges, towers, offshore platforms and so on. Some advance technologies for infrastructure health monitoring have been caused much more attentions, in which the wireless sensor network is recently received special interests. A Wireless Sensor Network (WSN) is a distributed system consisting of a base station and n wireless sensor nodes endowed with radio transceivers. The data being sensed by the sensor nodes in the network is eventually transmitted to a base station, where the information can be accessed. The data from base station is used to provide information on structural load and response characteristics, comparison with design, optimization of inspection, and assurance of continued structure health. Automated data processing and analysis provides information on important structural and operational parameters.

In this paper, a WSN is proposed for health monitoring of the offshore platform, and a laboratory prototype was designed and developed to demonstrate the feasibility and validity of the proposed WSN. In the laboratory prototype, wireless sensor nodes were deployed on a model of offshore platform, a Wireless Sensor Local Area Network (WLAN) transfers the simulated data among personal computer and microsensor nodes peripherals without cables. Based on processing and analysis of the structural response to loadings (accelerations, displacements, and strains), the proposed WSN is shown to be effective for health monitoring of large offshore structures. Advantages of this system over conventional structural health monitoring systems include continuous unattended monitoring, reduced costs associated with field data collection, instant access to data files and graphs by project team members.

1 INTRODUCTION

The process of implementing a damage detection strategy for aerospace, civil and mechanical engineering infrastructure is referred to as structural health monitoring (SHM)[1]. Health monitoring and damage detection encompass approaches for detecting the onset, propagation or effects of damage or degradation in structures and
In recent years, some advance technologies for infrastructure health monitoring have been caused much more attentions, in which the wireless sensor network (WSN) is received special interests. A Wireless Sensor Network (WSN) is a distributed system consisting of a base station and n wireless sensor nodes endowed with radio transceivers. The data being sensed by the sensor nodes in the network is eventually transmitted to a base station, where the information can be accessed. This has been enabled by the convergence of three key technologies: digital circuitry, wireless communications, and Micro ElectroMechanical Systems (MEMS).

In contrast to conventional SHM system, a WSN enables reliable monitoring and a better control over the sensor nodes from remote locations. A WSN may be distributed rapidly and without modification to the structures and systems. Wireless sensors may also be applied in areas where volume and mass constraints limit the application of conventional wireline interface sensors. WSN can also improve remote access by connecting the base station to other networks, like internet, using wide-area wireless links [4]. For the applications of WSN, a wireless modular monitoring system (WIMMS) was developed for civil structures to change the practices of using extensive cabling and high cost labor [5]. Mainwaring et al. [6] provided an in-depth study of applying WSNs to real-world habitat monitoring, and the current developed network consists of 32 nodes.

In this paper a laboratory prototype for offshore platform health monitoring is proposed and developed. The design and implementation of the hardware and software modules in the prototype is discussed. Finally, our progress to date in developing the system is presented.

2 PROTOTYPE OF WSN FOR HEALTH MONITORING SYSTEM

We have developed a prototype development for experimenting with wireless sensor networks. This prototype is designed based on the specific application requirements. The system consists of two subsystems, one is a local wireless measuring system of wireless nodes and base station and another is a remote operating system of personal computers. By employing wireless LAN (WLAN) protocol and products, the subsystems are linked via two wireless access points (WAPs), as shown in Figure 1.
In real-world applications, the local wireless measuring system will be installed on satellite offshore platforms which none work on it and far from the center offshore platform. The center offshore platform is managing and monitoring up to 31 satellite offshore platforms. So the remote system installed on the center offshore platform will be required to configure and operate the local measure system through IP-based wireless network.

The main task of local wireless measuring system is to measure changes in dynamic response of the structure and transmit data to the local Server. The software running on the Server will save and analyze all the transmitted data. This will reduce communications overhead greatly. The remote health monitoring system retrieve data from local wireless measuring system via wireless LAN (WLAN), the center unit of the remote system will assess the condition of the structure and display data in real-time. To provide data to remote end-users, the web server included in the remote system will propagate the data to the Internet and users can access and browse the processed data with Browser.

3 COMPONENTS OF THE SYSTEM

3.1 Local Wireless Measuring System

The data acquisition portion of the structural health monitoring process involves selecting the types of sensors to be used, selecting the location where the sensors should be placed, determining the number of sensors to be used, and defining the data acquisition/storage/transmittal hardware[1].

3.1.1 Wireless Sensor Node

In our development, we are using UC Berkeley MICA Motes as the sensor nodes (shown in Figure 2). The MICA Mote is a second generation mote module used for research and development of low power, wireless, sensor networks. The MICA Mote is the basic component of the WSN. It consists of plug-in sensor boards, TinyOS Distributed Software Operation System, Atmega 128L processor, 916MHz transceiver, Attached AA (2) battery pack.

Figure 2: MICA Mote (top) next to MIB Board

The hardware of the wireless node consists of a small, low-power radio and processor board (known as a mote processor/radio, or MPR, board, shown in Figure 3) and one or more sensor boards (known as a mote sensor, or MTS, board, shown in Figure 4).

Figure 3: MPR Board

Figure 4: MTS Board

The MPR modules contain various sensor interfaces, which are available through a small 51-pin connector that links the
MPR and MTS modules. The interface includes an 8-channel, 10-bit A/D converter; a serial UART port; and an I2C serial port. This allows the MPR module to connect to a variety of MTS sensor modules, including MTS modules that use analog sensors as well as digital smart sensors. The MPR module has a guaranteed unique, hard-coded 64-bit address, which is the Digital ID from Dallas Semiconductor. Figure 5 shows a block diagram of the MPR module [7].

Figure 5: The MICA processor/radio board has all the necessary electronic components to interface with a wide variety of MTS sensor modules, including MTS modules that use analog sensors as well as digital smart sensors.

3.1.2 Base Station

By plugging the processor/radio board into a standard PC interface board (known as mote interface, or MIB, board, shown in Figure 6), the MPR module can also function as a base station. The base station provides for data collection, monitoring for correct operation of the network.

3.1.3 Wireless Communication

The radio is the most important component of the MPR module because it represents the real-world communication conduit. The radio consists of a basic 916 MHz ISM band transceiver, antenna, and collection of discrete components to configure the physical layer characteristics, such as signal strength and sensitivity. It operates in an ON/OFF key mode at speeds up to 50 Kbps. With an ISM radio link, the wireless sensor nodes can communicate with each other and the data will be transmitted to the base station for post-processing.

3.1.4 Development Environment

TinyOS is a very small operating system developed by UC Berkeley which provides a base framework and development environment that functions well under extreme constraints of power, size, and cost. As a tiny microthreaded OS, TinyOS components composed of three parts, a .c file, a .comp file, and a .desc file [8]. Component files (.comp) are similar to .h files in that they specify an interface to a component. .c files (source files) are where TinyOS code resides. The .desc file is where components are linked together in a manner similar to a circuit diagram. The easiest way to start writing TinyOS code is to take existing code and modify it slightly.

3.1.5 Local Server

The local Server consists of a Database Server and a Computational Server. When monitoring in-service offshore platform, many structural response to loadings (accelerations, displacements, and strains) to be permanently or regularly monitored, the tasks of assuring the long term management of the large volume of measured data and the short term and dynamic sensor configuration can quickly become problematic. For this reason, two databases are implemented based on large database management system such as Sybase and Oracle. One of the databases is a real-time database for the sensing data from various types of sensors. The other is a static database for processed data storage. For the changes in the physical properties from
damage may be inferred from changes in the identified modal characteristics using suitable algorithms, a computational server is needed to run the structure analytical software. Algorithms needed to analytical model will produce a large mount of data, these data also be stored in the static database.

3.2 Remote Operating System

The remote operating system will be installed on the center offshore platform and linked with the local system via two wireless access point. The data are retrieved from the local database server and transmitted to the remote hardware capture units.

Wireless local area networks (WLANs) constitute one of the most dynamically developing fields of telecommunications. They play a very important role in the health monitoring system as a provider of easy and unconstrained access to the wired infrastructure. They can be installed places that are very difficult to wire. WLANs may be temporary or operational for a short period of time, where installation of wired networks is impractical.

The information can be made available to building managers in real-time or whenever a predetermined threshold level is reached. Upon retrieving this information, the analysis software can assess the current condition of the offshore platform. The display software allows the user living and working on the center offshore platform to observe all the transmitted data in real-time.

To provide data to remote end-users, the web server included in the remote system will propagate the data to the Internet and users can access and browse requiring data by Browser. In view of the safety of the system, only the developers or administrators can configure or access every component of the system.

4 CURRENT PROGRESS

A prototype WSN system for offshore platform health monitoring has been designed and developed. And current research efforts are focused on integrating the prototype wireless sensors and the other hardware into a complete offshore platform health monitoring system.

The wireless sensing unit used in our experiment is MTS board which includes light, temp, acoustic, sounder, magnetic and accelerometer. The ADXL202 is manufactured by Analog Devices and is a low cost, low power, complete 2-axis accelerometer with a measurement range of either +2 g/+10 g. The ADXL202 can measure both dynamic acceleration and static acceleration. The bandwidth of the accelerometer may be set from 0.01 Hz to 5 KHz via capacitors Cx and Cy. The accelerators are deployed on the model to measure the vibration of the structure.

Utilization of state-of-the-art wireless technology give us the ability to set up a WLAN, this will not only means fewer expenses and hassles, but provide the data to the users in the office and implemented the remote wireless operation system prototype. The Linksys WAP11 was selected for the proposed prototype of the wireless remote operating system. The WAP11 is interoperated with IEEE 802.1b(DSSS) and has a high-speed data transfer rate up to 11 Mbps. The Point's high-powered antennae offer a range of operation up to 1500 feet, providing seamless roaming throughout the LAN infrastructure. The extensive operating range of the WAP11 supports up to 300 ft. (indoors) and 500 ft. (outdoors).

After connected the Access Point to the wired network, the Setup Wizard will take all the steps necessary to get the Access Point connecting the wireless network to the wired network and communicating more efficiently. The Access Point offers four modes of operation: Access point, Access Point Client, Wireless Bridge, and Wireless Bridge Point to MultiPoint, as shown in Figure 7. To make a wireless connection between two wired networks, select Wireless Bridge. This mode connects two physically separated LAN segments with two Access Points. This will transfers the simulated data among personal computer and microsensor nodes peripherals without cables.
In the laboratory prototype, the main components of the WSN include a base station and three wireless nodes. The base station was plugged into a personal computer to receive the data from the sensor nodes, and the wireless nodes were deployed on a two floors test structure (shown in Figure 8) to measure the acceleration response of the structure. The test structure is one of the components of a shake table system developed and manufactured by Quanser Consulting. This system can be used to demonstrate vibration modes of a simple structure. Three accelerometers are supplied with the system. The data out of these accelerometers can be used to compare with the data measured by the wireless sensor nodes.

For in-depth study of the proposed system and applying the system to real-world offshore platform, a offshore platform model of in-service offshore platform (JZ20 – 2MUQ) which located in Bohai of China has been setup, as shown in Figure 9.

To display the processed data on a graphical interface, we are developing the user interface with LabWindows/CVI language of NI based on TinyOS. The integrated LabWindows/CVI environment features code generation tools and prototyping utilities for fast and easy C code development. It offers a unique, interactive ANSI C approach that delivers access to the full power of C with the ease of use of Visual Basic. LabWindows/CVI also contains many features that make developing measurement applications easier than developing in traditional C environments.

5 CONCLUSION

Structural Health Monitoring (SHM) is very important for the offshore platforms because of the abominable environment. A WSN prototype for health monitoring of in-service offshore platform is proposed and developed. To evaluate the proposed prototype, we deployed it in our laboratory. Mica motes from UC Berkeley include microsensors, signal processing, computation and low power wireless networking were deployed on a Two floors test structure and a test model of in-service offshore platform separately. Utilization of the WLAN technology and Wireless...
Access Points, the processed data output of the sensing units in laboratory were transmitted to the server positioned in the office via wireless link. The ultimate goal of the study is to suggest WSNs for health monitoring system of in-service offshore platforms and the other civil infrastructures.

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7 REFERENCES


