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Design and Implementation of Zigbee Wireless Bus Monitoring System

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Abstract: This paper deals with the implementation of an intelligent bus monitoring system based on current challenges and problems. Home network based applications are very diverse and the remote monitoring and control areas have been studied. Recently, Zig-Bee has become one of the most promising technologies for home networks and integrated sensing technologies such as global positioning system (GPS), general packet radio service (GPRS)and geographic information system (GIS) are used to monitor the movement of a bus. A new theoretical framework and ruled based decision algorithms are developed for the system. An experimental setup is developed for the prototype implementation. The results show that the choice of integrated technologies used in the system is suitable to monitor and manage a vehicle transportation system.

Keywords: Zig-Bee; GRPS; Bus Monitoring System; Hardware Design; Software Design.

I. INTRODUCTION

Thanks to the rapid development of information technology and growth of the Internet through high speed networks, network environments have even been changed from office oriented environments based on business industries and public institutions to the interconnection of digital electronics in the home networks. Home network based applications are very diverse and the remote monitoring and control areas have been studied. Recently, Zig-Bee has become one of the most promising technologies for home networks. Zig-Bee is a specification for a suite of networking, security and application software layers using small, low-power, low data rate communication technology based on IEEE 802.15.4 standard for personal area networks. There have been various studies on Zig-Bee based home networks. To realize remote home automation based on Zig-Bee, implementation issues of home gateway and device nodes are proposed. It presents hardware platform consideration and software implementation for each of them. Similarly, hardware design issues are discussed for various home devices such as wireless communications transceiver modules base, USB expansion base and control switches for electrical appliances in a room. Also, an effective architecture for dynamic integration of ad hoc Zig-Bee home network devices into OSGi (Open Service Gateway Initiative)-based home gateways is discussed. An ad hoc Zig-Bee home network device is represented by a device proxy service in the proposed architecture so that it can be dynamically registered, discovered, accessed and unregistered just like a common OSGi service gives a way to construct Zig-Bee wireless sensor networks and implement remote monitoring and control by a GSM module describes the structure composition of the smart home system based on Zig Bee and gives a system design concept and implementation approach. Moreover, owing to the rapid growth of mobile technology, high-performance smart phones are widespread and in increasing cases they are utilized as a terminal device.

An intelligent system is a system that is able to act according to its situation without having to be instructed by humans. For instance, in an intelligent car cruise system, image processing is used in order to detect the car, base on the image signal obtained. In general, an intelligent system consists of a data processor, which can be an expert rule-based system or a machine learning system, such as an Artificial Neural Network (ANN), which is usually used as a data trainer. A machine learning system fed into an intelligent system enables the overall system to classify current events on its own. In addition to feeding a learning machine into a system, an intelligent system can also consist of a simple formula that produces a series of inputs and outputs, which can be interpreted by a finite-state machine. Bus monitoring and management system intelligence studies fall under the category of Intelligent Transportation Systems(ITS), and ITS includes a public transportation control framework, road traffic management, and the application of traffic control. There have been a number of previous studies addressing intelligent transportation and vehicle monitoring systems. Intelligent transportation enables various technologies to be applied in transportation systems and is defined as the use of information and communication technologies to collect, process, and transmit traffic data to transport users and operators.

Vehicle monitoring systems, however, only take vehicles into account; for example, auto-positioning systems can be applied to vehicle monitoring, vehicle control, and vehicle management. As mentioned previously, there have been a number of studies focused on transportation and vehicle monitoring systems. However, only a few studies have incorporated RFID technology and have integrated communication technologies in VMS integrates RFID with GIS and GPS with Visual Basic.Net and Visual Earth as the software platform to build a real-time vehicle management system. A mobile RFID system had also been realized to ensure the safety of vehicles, in which RFID technology is embedded with Web-GIS. RFID is also used to track vehicles in parking lots. The incorporation of RFID in vehicles enables the vehicles to be tracked without using GPS. Although the tracking is not continuous, unlike GPS, the location of the vehicle can be easily determined at checkpoints where the RFID communication devices connect with each other. RFID in VMS is also beneficial in preventing car theft.

As mentioned earlier, GPS is one of the core technologies implemented in this research to enable effective wireless navigation system. GPS has been used widely for tracking and monitoring purpose and it functions on the wave radiation on satellites. Even though GPS is used vastly for navigation, it is still lacking and prone to errors. Chiang et al. stated that there are two important error sources for GPS, which are phase multipath and direction-dependent variations in the antenna phase center. In mentioned about the signal multipath problem in GPS, which occurs when a signal faces obstacles along its way to? the GPS receiver on ground, and its correction, while the error factor in the GPS based station reporting system was analyzed by GPS functions were further enhanced when Lundberg presented two new closed form algorithms as an alternative for the GPS static positioning solution method was put forward on error compensation of velocity and position coordinates by the GPS using neural network while in a study by artificial neural networks (ANN) was utilized. Although corrections and modifications had been made, GPS still faces challenges that can still be solved.

II. BACKGROUND TECHNOLOGIES

A. IEEE 802.15.4

IEEE 802.15 is a working group for the standardization of WPAN (Wireless Personal Area Network). IEEE 802.15.4 is one of the seven task groups which are included in it. The first edition of the 802.15.4 standard was released in May 2003. IEEE 802.15.4 specifies the physical layer (PHY) and media access control (MAC) for low-rate WPAN. WPANs are used to convey information over relatively short distances. It focuses on low-cost, low-speed ubiquitous communication between devices. Unlike wireless local area networks (WLANs), connections effected via WPANs involve little or no infrastructure. This feature allows small, power-efficient, inexpensive solutions to be implemented for a wide range of devices. The basic framework conceives a 10-meter communication range with a transfer rate of 250 kbit/s. Important features include real-time suitability by reservation of guaranteed time slots, collision avoidance through CSMA/CA and integrated support for secure communications. Devices also include power management functions such as link quality and energy detection. Several standardized and proprietary network layer protocols run over 802.15.4-based networks, including IEEE 802.15.5, Zig-Bee, 6LoWPAN, Wireless HART, and ISA100.11a. Potential application areas include the following: sensors, actuators, interactive toys, remote control, industry networks, home automation and so on.

B. Zig-Bee

Zig-Bee is a standards-based technology that addresses the unique requirements of most remote monitoring and control and sensory network applications. Zig-Bee builds upon the physical layer and medium access control defined in IEEE 802.15.4 for low-rate WPANs. The specification goes on to complete the standard by adding four main components: network layer, application layer, Zig-Bee device objects (ZDOs) and manufacturer defined application objects which allow for customization and favor total integration. The initial markets for Zig-Bee included Consumer Electronics, Energy Management and Efficiency, Health Care, Home Automation, Telecommunication Services, Building Automation, and Industrial Automation. The cores Zig-Bee specifications define smart, cost-effective and energy-efficient mesh networks. It is a self-configuring, self-healing system of redundant, low-cost, very low-power nodes. Zig-Bee is available as two feature sets, Zig-Bee PRO and Zig-Bee. Both feature sets define how the Zig-Bee mesh networks operate.

C. Home Network Technologies

A home network is a residential local area network (LAN) for communication between digital devices typically deployed in the home, usually a small number of personal computers and accessories, mobile computing devices, mobile phones, digital TVs, PDAs and so on. An important function is the sharing of Internet access, often a broadband service provisioned by fiber-to-the-home or via Cable Internet access, Digital Subscriber Line (DSL) or mobile broadband by Internet service providers (ISPs). In a broader sense, it includes software and services for integration and operation of information appliances in addition to wired or wireless network devices. Home networking technologies can be classified into two kinds: wired and wireless. The telephone, power-line, Ethernet and IEEE 1394 exist as wired home network technologies. As wireless home network technologies, wireless LAN, Home RF, Hyper LAN, Bluetooth, UWB (Ultra Wide Band) and Zig Bee is representative. Since wireless networking solutions based on the spread of mobile devices have emerged they can be applied to home networks also.

III. DESIGN OF REMOTE MONITORING AND CONTROLLING SYSTE

This section deals with the design of remote monitoring and controlling systems. To design a system, we considered a

home automation network. The system architecture is presented in Fig.1.

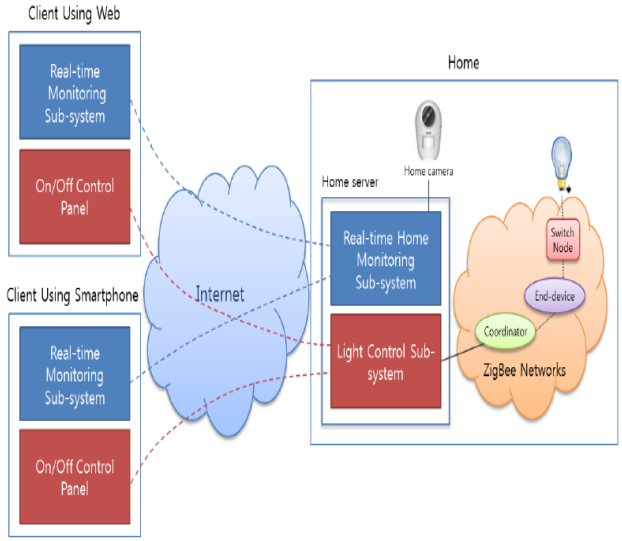

Fig.1. System Architecture.

The system consists of a real-time home monitoring sub-system and a light control sub-system. A home server with a home camera caters for home status through video to client. It also works as a home gateway to provide interoperability between the heterogeneous Zig Bee and Internet and local and remote control over the home's light devices through the light control sub-system. A client can access the home server through a web service or smart phone. The client can monitor home status through a real-time monitoring sub-system and control the lights through the On/off control panel.

A. Real-time Monitoring Sub-system

The real-time monitoring sub-system captures images of the area of the home to be monitored and serves the client who accesses the server through the web or a smart phone.

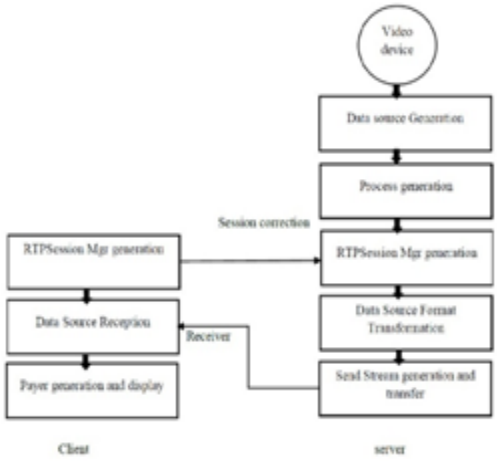

Fig.2. Operation Processes of Real-time Monitoring Sub-system.

Fig.2 shows the operation process of the real-time monitoring sub-system. The server finds a video device and captures images. Then, it generates captured data and transforms the data format for RTP communication. After that, it generates the session manager and streams media data to the client. A client using the web or a smart phone generates the session manager and connects to the server. Then, it receives media data and displays the video. In this way, the client can monitor the in-home status in real-time.

B. Light Control Sub-system

Light control sub-system is composed of a server which works as a gateway, Zig Bee coordinator, end-device, switch node and a light as shown in Fig.3.

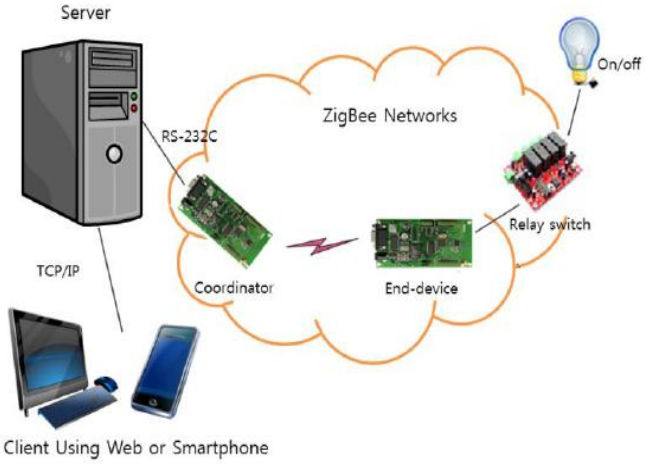

Fig.3. Light Control Sub-system.

The operation of the sub-system is as follows.

1. A client program maintains a user interface which contains an on/off control panel.
2. A server which works as a gateway receives control commands from the client and relays the command to the Zig Bee coordinator through the RS-232C serial communication.
3. The coordinator relays the control command which is received from the server to the end device through RF communication.
4. The end device receives the command from the coordinator and controls the port of the switch node.
5. The switch node controls the switch of the light.

Fig.4.Busstop section.

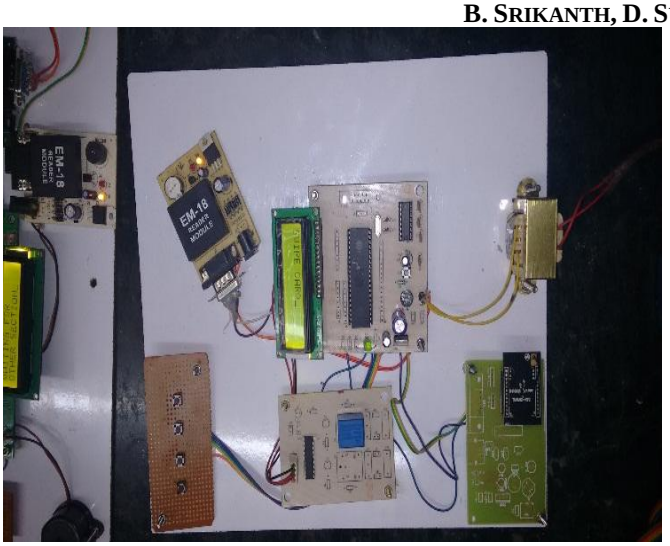

Fig.5.Bus section.

Zig Bee based remote controlling can be applied in several ways. In this paper, we considered a simple light control and adopted it for a remote control sub-system.

IV. SOFTWARE DESIGN

Software design includes application software design and Zig Bee protocol software design. Station monitor itself is a Zig Bee network coordinator, plus GPRS module. After power-on, the MCU of station monitor first initializes GPRS module and Zig Bee protocol stack. The next step for MCU is to scan the channel and assess the idle channel. According to the analysis of channel state, MCU will select appropriate operating channels and select the right network identifier. Then MCU starts the Zig Bee network and sends data frames up to network, waiting for the connection request from some one Zig Bee device. If MCU has received one message of connection request, it will certify whether the Zig Bee device is legal. If yes, MCU can now issue a command to allow Zig Bee device connecting with it and establish connection. When connection established, station monitor will obtain the information of Zig Bee device's identification number, which is on behalf of one bus where the Zig Bee device is installed. MCU will register the identification number and at the same time, send one message about what time the bus shall arrive at this bus station. Station monitor can connect with not just only one Zig Bee device one time, so will it with information registration [7] [8].

During the time that the bus is leaving bus station, the special signal intensity will decrease continuously. If the signal intensity decreases to some degree, the connection between bus and station monitor will automatically be eliminated. And corresponding, the information of identification number in registration table will be removed. Then the MCU of station monitor send one message that the bus has left the bus station. The workflow of station monitor is shown in Fig.6-a. For Zig Bee device-wireless identification device, which is installed on bus, it first initializes the Zig Bee protocol stack after power-on. Then wireless identification device starts scanning the channel to find the nearest Zig Bee coordinator. When it detects the data frames sent from Zig Bee network coordinator and meanwhile, wireless identification device sends one message of establishing connection request if the signal intensity is stronger than a certain degree. Once connection is established, the wireless identification device will obtain the identification number of Zig Bee coordinator, and be aware of which station the bus is located; so the bus can report bus station information according to the station identification number, to achieve the purpose of automatically and accurately reporting station. When the bus is leaving bus station, the special signal intensity will decrease continuously. If the signal intensity decreases to some degree, wireless identification device will send one message of request for disconnecting the network which it has joined and, the connection will be eliminated. The workflow of station monitor is shown in Fig.6-b.

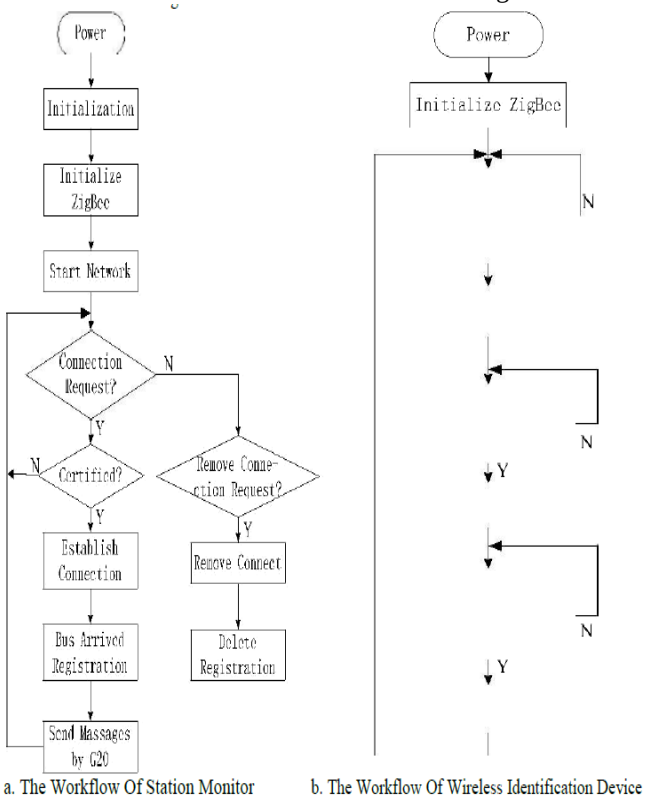

Fig.6. The workflow of system components.

V. CONCLUSION

The intelligence implemented in the bus monitoring system can be achieved by compiling and feeding all the proposed theories and algorithms for RFID and other sensing technologies into the system. The ability of the system to act on its own can reduce the manpower required at the monitoring center. Bus drivers will also be more punctual to the bus schedules that have been established, resulting in a more efficient bus circulation system. This paper proposes design and implementation of a remote monitoring and controlling system based on Zig Bee networks. Real-time remote monitoring is implemented with JMF which is a multimedia extension API of Java. The remote controlling is implemented using Zig Bee networks. The client program in a

smart phone is implemented on the android platform. Clients can monitor their homes and send light control commands using the web or a smart phone. This system can be applied in many areas such as elderly protecting systems, cultural heritage or forest fire monitoring systems, managing systems for agricultural cultivation and so on. As a future work, we consider expansion of the system using various sensors and actuators.

VI. REFERENCES

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