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The Implementation of Indoor Location System to Control ZigBee Home Network

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Abstract: This paper implements the indoor location system to control ZigBee home network. Indoor location system requires periodic update data from a location information service to determine the user's current position data. This paper implements the indoor location home control system which uses ZigBee. We have implements IPS-M (Indoor Position System-M), IPS-I (Indoor Position System-Infrastructure), IPS-G (Indoor Position System-Gateway) to indoor location based home control system. The IPS-I device has active beacons that periodically transmit signals to a passively listening IPS-M device, which in turn estimates distances to the beacons. Because the active mobile architecture receives simultaneous distance estimates at multiple receivers from IPS-M device, it is likely to perform better tracking than the passive mobile system in which the device obtains only one distance estimate at a time and may have moved between successive estimates. In the IPS-M (Indoor Position System-Mobile) architecture receives wireless signals (e.g., radio and ultrasound) from an IPS-I (Indoor Position System-Infrastructure) device, allowing the IPS-I to track the IPS-M. We implements ZigBee stack to control home network system with indoor location data.

Keywords: ZigBee, Home Network, Indoor Location System

1. INTRODUCTION

Location-aware or context-aware devices and applications let users view and interact with location dependent information and resources. In outdoor settings, Global Positioning System-enabled applications with access to specialized geographic databases have had a significant impact on military operations, civilian navigation and surveying, commercial shipping and supply-chain management, aerial photography, precision agriculture, and many other areas over the past decade. This paper describes these applications along with the device infrastructure and RF communication required to support them [1, 2].

The Bristol indoor positioning system has a design similar to Cricket in that it uses active beacons and passive receivers. The system uses PIC processors, which limits the amount of computation possible on each node in the system. This limit forces the beacons to be placed in a regular pattern on the ceiling, which in turn causes the installation of the beacons to be more difficult. The Place Lab project uses existing WiFi Access Points (like RADAR) to determine location information for Web applications. Place Lab hopes to provide a community driven database of WiFi locations for mobile users. Applications can then compare the signal strength of available access points to the Place Lab database to determine a coarse-grained location [3, 4, and 5].

Context-aware applications, which adapt their behavior to environmental context such as physical location, are an important class of applications in emerging pervasive computing environment. Examples include location-aware applications that enable users to discover resources in their physical proximity, active maps that automatically change as a user moves, and applications whose user interfaces adapt to the user's location. A significant amount of previous work has focused on providing device position capability indoors, including the Active Badge, Bat, RADAR, and Cricket systems. An important aspect of context, which is related to physical position, is the orientation of a device (or user) with respect to one or more landmarks in a region. A pervasive computing application can benefit from knowing this information, for instance by providing the ability to adapt a user interface to the direction in which a user is standing or pointing [6-10].

In this paper, we implement the indoor location system which uses ZigBee based home control system. ZigBee is a low data rate, low power consumption, low cost; wireless networking protocol targeted towards automation and remote control applications. ZigBee is expected to provide low cost, power connectivity for equipment which needs battery life as long as several months to several years. But it does not require data transfer rates as high as those enabled by Bluetooth. In addition, ZigBee can be implemented in mesh networks larger than is possible with Bluetooh.

In this paper, we implement a home control with indoor location system which uses ultrasound, RF signal (TOA: Time of Arrival).

2. ZIGBEE NETWORK

We have implemented ZigBee stack to control home network system. The architecture of our ZigBee stack is Fig 1. We have used cc2420 RF chip that is compliant of IEEE 802.15.4 and implemented GTS function to real-time QoS services. We have planed to porting CC2431 RF chip and application programming porting layer that is easy application programming for application programmers.

The Fig. 2 shows operating system in ZigBee stack that happens every 320 usec interrupts to process task, callback functions. It processes each protocol stack in case of happening events and message communication to each protocol stack layer.

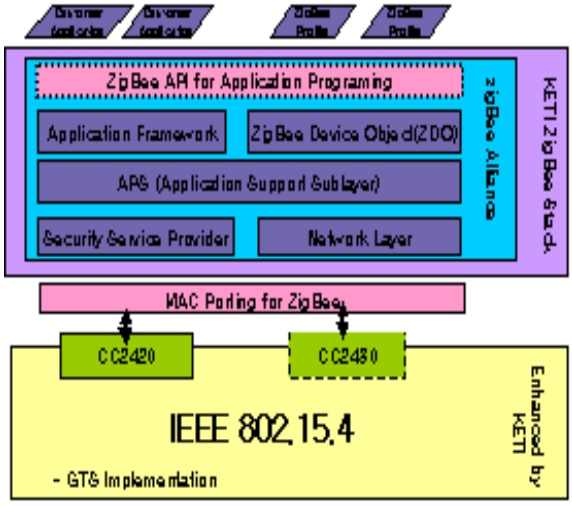

Fig. 1 ZigBee Stack Architecture

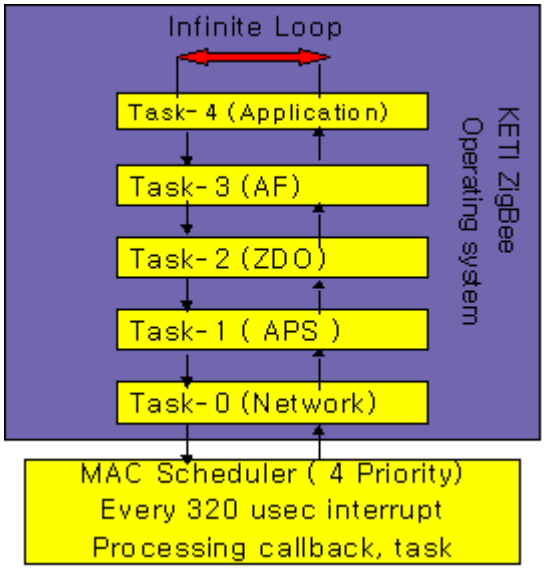

Fig. 2 KETI ZigBee Operating System

The ZigBee network layer is required to provide functionality to ensure correct operation of the IEEE 802.15.4-2003 MAC sub-layer and to provide a suitable service interface to the application layer. To interface with the application layer, the network layer conceptually includes two service entities that provide the necessary functionality.

These service entities are the data service and the management service. The NWK layer data entity (NLDE) provides the data transmission service via its associated SAP, the NLDE-SAP, and the NWK layer management entity (NLME) provides the management service via its associated SAP, the NLME-SAP. The NLME utilizes the NLDE to achieve some of its management tasks and it also maintains a database of managed objects known as the network information base (NIB).

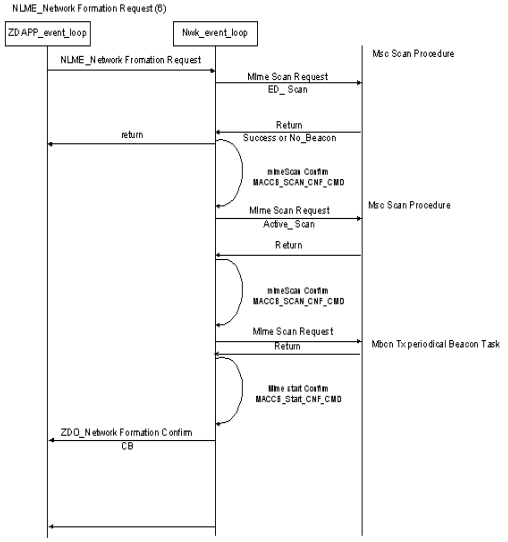

Fig. 3 ZigBee Network Formation

2.1 Network Layer Data Entity (NLDE)

The NLDE shall provide a data service to allow an application to transport application protocol data units (APDU) between two or more devices. The devices themselves must be located on the same network. The NLDE will provide the following services:

— **Generation of the Network level PDU (NPDU).** The NLDE shall be capable of generating an NPDU from an application support sub-layer PDU through the addition of an appropriate protocol header.

— **Topology specific routing.** The NLDE shall be able to transmit an NPDU to an appropriate device that is either the final destination of the communication or the next step towards the final destination in the communication chain.

2.2 Network layer management entity (NLME)

The NLME shall provide a management service to allow an application to interact with the stack. The NLME shall provide the following services:

— **Configuring a new device.** The ability to sufficiently configure the stack for operation as required. Configuration options include beginning operation as a ZigBee coordinator or joining an existing network.

— **Starting a network.** The ability to establish a new network.

— **Joining and leaving a network**. The ability to join or leave a network as well as the ability for a ZigBee coordinator or ZigBee router to request that a device leave the network.

— **Addressing**. The ability of ZigBee coordinators and routers to assign addresses to devices joining the network.

— **Neighbor discovery**. The ability to discover, record and report information pertaining to the one-hop neighbors of a device

— **Route discovery**. The ability to discover and

record paths through the network whereby messages may be efficiently routed.

— **Reception control.** The ability for a device to control

The Fig. 4 shows the debugging method to develop ZigBee stack. We have used serial print function to print debug messages. In interface with PC serial port, we print ouput message with hyper terminal program.

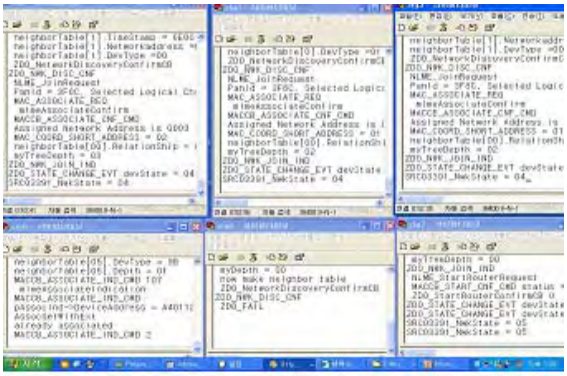

Fig. 4 ZigBee Stack Debugging Method

3. Indoor Positioning System

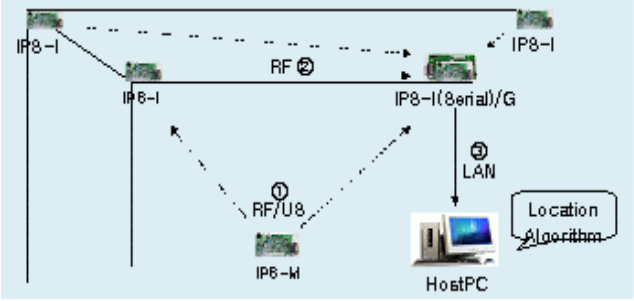

Fig. 5 Indoor Location Algorithm

- Indoor Location Algorithm

1. IPS-I happens RF, Ultrasound signals every clock intervals.
2. IPS-I calculates between IPS-M distance and acknowledges IPS-I/G
3. IPS-I/G transmits to Host PC by Ethernet network.

In this paper, chipcon 2420 was used for 2.4GHz band ZigBee compliant RF chip. The micro controller is ATmega128 with 18 bits, a very good low power feature. The Chipcon 2420 has the following features.

- 2.4 GHz IEEE 802.15.4 RF transmission/reception
- DSSS-based modem 250 kbps
- RFD, FFD operation
- Digital RSSI/LQI support

Fig. 5 is a home control system based on user positioning. It calculates position data with ultrasound and RF which is TOA (Time of Arrival). It transmits home appliances to control commands about position data through the positioning server system. When the positioning system's position information data is transmitted to the communication module through the 2.4GHz ZigBee-based communication module, actuation command is executed according to this data.

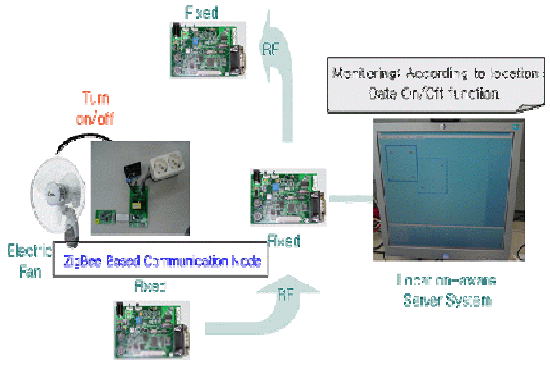

Fig. 6 Home appliance control system using positioning data

3.1 IPS-G (Indoor Positioning System - Gateway)

IPS-G (Indoor Positioning System - Gateway) is a system that is performing the role of linking with IPS-M (Indoor Positioning System - Mobile) to create a packet of data collected from IPS-M using Ethernet and transmitting it to the server group.

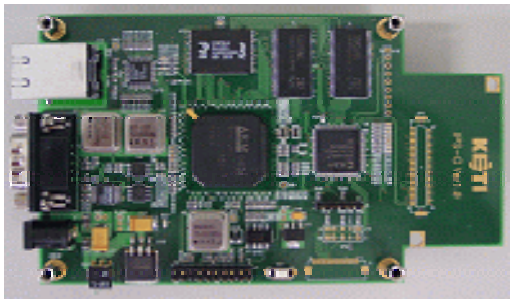

Fig. 7 IPS-G (Indoor Positioning System –Gateway)

- Hardware Components
  . 133MHz Samsung ARM9 Core Processor
  . 512Mbit SDRAM with 32 bit data bus
  . 64Mbit Flash Memory with 16 bit data bus
  . Xilinx CPLD 95144XL with 144 micro cells
  . Console Interface support
  . 10/100 Mbps Ethernet interface support
  . Sensor board interface support
  . Power : 5V

3.2 IPS-I/M (Indoor Positioning System – Infrastructure/Mobile)

IPS-I/M is a system which is performing the role of recognizing positions using the method of measuring distance through time difference of the RF signal and the ultrasound signal.

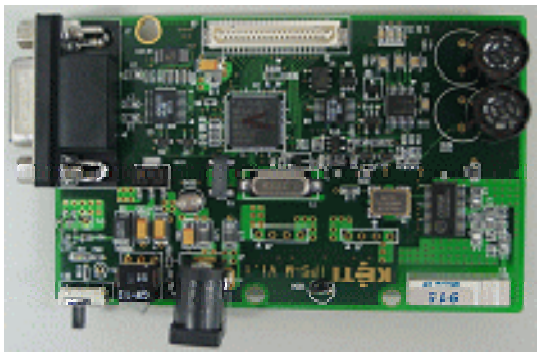

Fig. 8 IPS-I/M System

- Hardware Components
  . ATmega128L with an 8 bit AVR core
  . CC2420 RF transceiver using 2.4GHz RF
  . Ultrasound sensor's transmission and reception platforms with central frequency of 40 KHz
  . Micro signal amplification platform for ultrasound reception
  . Voltage amplification platform for ultrasound reception
  . Digital ohmmeter to control ultrasound reception quality and level

ATmega128 plays the role of a central function, transmitting RF signals through CC2420 and ultrasound signals at the same time. On the other hand, the ATmega128 recognizes that ultrasound signals are received through the process of amplification, filtering, inspection, and comparison as they are received through the ultrasound sensor platform among received signals.

4. Conclusion

This paper is the second year development result regarding development of a positioning technology in the smart home, which is a part of the regional industrial technology development project of Gyeongnam. Indoor location technology in the smart home is based the ubiquitous home service.

It is a theme vigorously studied and developed all over the world. During the second year, the technology of positioning system using ultrasound sensor and RF was developed. Results of the second year project concerned positioning hardware, and development for IPS-M/I (Indoor Positioning System-Mobile/Infrastructure), IPS-G (Indoor Positioning System-Gateway), and various sensor interface boards were completed. We have implement ZigBee based home control system with indoor location system.

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