Home Automation Control With Indoor Position System

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ABSTRACT

We implement indoor position system which requires periodic updates from a location information service to determine the user's current position. We use this position data to control home automation with IEEE 802.15.4 complient chipset which is CC2420. IEEE 802.15.4 is a nework designed for low-cost and very low-power short-range wireless communications. IEEE 802.15.4 is a consortium formed by serveral leading semiconductor and industrial manufactures, and end users. One of the tasks of this organization is the definition of the networking support and applications profiles that will use IEEE Std 802.15.4-compliant transceivers. In the case of IEEE Std 802.15.4, the ZigBee Alliance is an organization that has led the development of the upper layers, through the definition of application profiles.

Keywords : Home Automation, Indoor Position System, IEEE802.15.4, ZigBee Alliance

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 Positining 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 infrastrucutre 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 [3,4,5].

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].

ZigBee technology is a low data rate, low power consumption, low cost, wireless networking protocol targeted towards automation and remote control applications. IEEE 802.15.4 committee started working on a low data rate standard a short while later. Then the ZigBee Alliance and the IEEE decided to join forces and ZigBee is the commercial name for this technology. ZigBee is expectd to provide low cost and low power connectivity for equipment that needs battery life as long as several months to several years but 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 automation with indoor position system which uses ultrasound, RF signal.

2. Home Automation Using Indoor Positioning Service

2.1 Home Appliance Actuator H/W based on ZigBee

<Figure 1> Home Appliance Control Actuator based on ZigBee

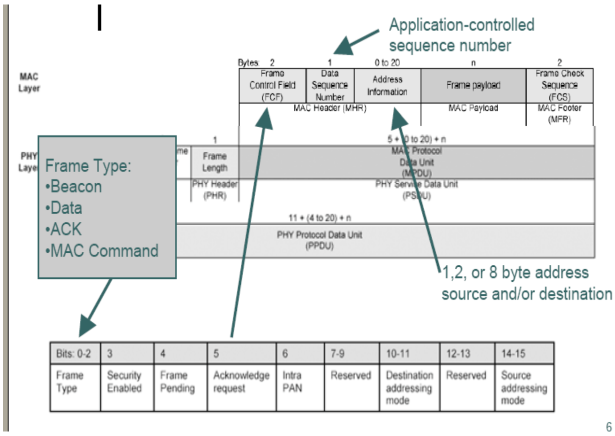
* SSR control circuit

The parts used for SSR control are Opto-coupler and Transistor. When the PWR1 input from the 2.4GHz wireless communication module is a signal for driving On/Off with logic of '0', the voltage of the Opto-coupler's Cathode terminal is reduced to induce electric current toward the photo diode within the opto-coupler. Light generated from the Photo Diode is used to induce electric current to the base of the Photo Transistor built in the opposite side, and electric current flows into the Photo Transistor. When there is no electric current, the SSR is left Off through R13/R14, and when there is electric current, the current induced through R12 raises the voltage in R13 to turn on the SSR with 4.2V voltage. The SSR control circuit using a Transistor is not used.

2.2 ZigBee-Based Home Control System using Positioning Data

All digital appliances in the home have built-in ZigBee modules, and through this device, a home control system that controls digital appliances has been realized. Of course, the sensor network module does not exist in digital appliances alone. Sensor network module may exist in walls, closets, or ceiling of the home. Such sensor network module does not have a special function, but simply delivers collected status data to the sensor network gateway, and receives commands from devices like the gateway to function as actuator.

The data format currently built follows the data format in IEEE 802.15.4.



<Figure 2> Data format according to IEEE 802.15.4 data structure

Data reception: Data formatted when receiving messages using a program called Listen, and through other communication nodes.

```
typedef struct TOS_Msg
{  /* The following fields are transmitted/received on the radio. */
  uint8_t length;
  uint8_t fcfhi;
  uint8_t fcflo;
  uint8_t dsn;
  uint16_t destpan;
  uint16_t addr;
  uint8_t type;
  uint8_t group;
 int8_t data[TOSH_DATA_LENGTH];
```

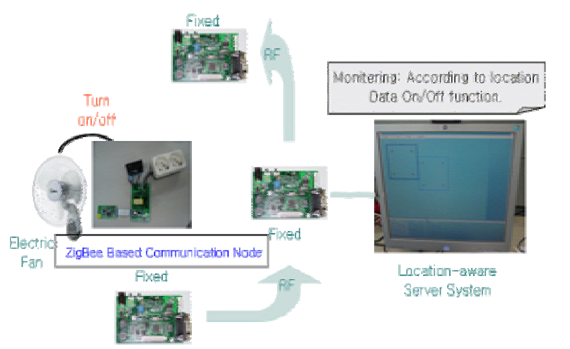
Data format when transmitting data

```
typedef struct {
   int nsamples;
   uint32_t interval;
} start_sense_args;
typedef struct {
   uint16_t destaddr;
} read_log_args;
// SimpleCmd message structure
typedef struct SimpleCmdMsg {
   int8_t seqno;
   int8_t action;
   uint16_t source;
   uint8_t hop_count;
   union {
     start_sense_args ss_args;
     read_log_args rl_args;
     uint8_t untyped_args[0];
   } args;
} SimpleCmdMsg;
```

In this paper, chipcon 2420 was used for 2.4GHz band ZigBee, and for RF transmission/reception. The micro controller is TI MSP430, with 16 bits, with a very good low power feature. 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

Figure 3 below is a home control system based on positioning realized in this paper, calculating position data with ultrasound and RF, transmitting home appliance 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.

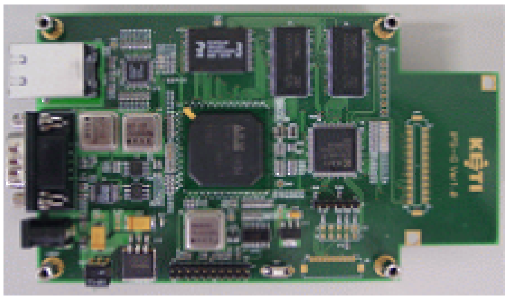


<Figure 3> Realization of home appliance control system using positioning data

3. Indoor Positioning System

3.1 IPS-G (Indoor Positioning System - Gateway)

IPS-G(Indoor Positioning System - Gateway) is a board 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 conveying it to the server group.



<Figure 4> IPS-G (Indoor Positioning System - Gateway)

1) 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 microcells
. Console Interface support
. 10/100 Mbps Ethernet interface support
. Sensor board interface support
. Power : 5V

3.2 IPS-M (Indoor Positioning System - Mobile)

IPS-M is a board performing the role of recognizing positions using the method of measuring distance through time difference of the RF signal and the ultrasound sensor, using the ultrasound sensor in addition to the RF signal of the sensor board mentioned above.

<Figure 5> IPS-M board

1) Hardware Components

. ATmega128L with an 8 bit AVR core

. CC1000 RF transceiver using 915MHz RF

. Ultrasound sensor's transmission and reception platforms with central frequency of 40KHz

. Micro signal amplification platform for ultrasound reception

. Voltage amplification platform for ultrasound reception

. Digital ohmmeter to control ultrasound reception quality and level

2) IPS-M Block Diagram

ATmega128 plays the role of a central function, transmitting RF signals through OC1000 and ultrasound signals through the ultrasound sensor 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. Also, RF signals have the structure of being received through CC1000.

4. Conclusion

This paper is the 1st year development result regarding development of a positioning technology in the intelligent home, which is a part of the regional industrial technology development project of Gyongnam. Positioning technology in the intelligent home is based on ubiquitous home service, a theme vigorously studied and developed all over the world. During the first year, the technology of positioning system using ultrasound sensor and RF was developed. Results of the 1st year project concerned positioning hardware, and development for IPS-M(Indoor Positioning System-Mobile), IPS-G(Indoor Positioning System-Gateway), and various sensor interface boards were completed. A prototype system for realization of home automation using position data was realized.

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