The Development of Integrated ZigBee/RFID Module and Remote Monitoring System

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Abstract. We developed integrated ZigBee/RFID module to combine 2.4 GHz USN (Ubiquitous Sensor Network) to 900 MHz RFID and monitoring system. This integrated ZigBee/RFID module keeps current RFID functions for wireless sensor network solution, supports for sensing functions with tags, and RFID reader and provides ad-hoc sensor network. In other words, it implements to combine "convergence of sensing functions" to "intelligent sensor network".

Keywords: RFID, ZigBee, integrated ZigBee/RFID module, remote monitoring system, wireless sensor network

1 Introduction

Even though ZigBee/RFID technology is the beginning step in the world, we produce and sell 2.4GHz ZigBee modules with TinyOS for ubiquitous sensor network (USN). If we have integrated USN/RFID solution to combine RFID to ZigBee, it will be outstanding technology in the world.

In current RFID system, RFID reader reads tag information and then sends reading data to server. It supports for only transferring data not sensing function. There is wired communication (RS-232, RS-422, RS-485, etc.) between RFID reader and server. This wired communication has disadvantage to invest high cost for cabling and duplicated cost for changing location. But, ZigBee/RFID does not need extra networking job when tag, reader, or server's location is changed. Also, it does not need extra cost because it does not need to be connected by cable.

In this paper, we suggested integrated ZigBee/RFID which keeps current functions with passive and active types. Also, it supports for communication between tags,

between tag and reader, and between tag and server. It will be appropriate for home networking required efficient cost. In Section 2, we explained the results of our research included the structure of integrated ZigBee/RFID module and 900MHz RFID reader protocol. In Section 3, we described remote monitoring system. In last Section, we conclude our research and mention our future work.

2 The results of our research

2.1 Integrated ZigBee/RFID Module

The integrated ZigBee/RFID module keeps current RFID functions with wireless sensor network solution and supports for tags and RFID reader with sensing functions and ad-hoc technology to provide sensor network. It implements “convergence of sensing functions” and “intelligent autonomous sensor networks”. Fig. 1 is the structure of integrated ZigBee/RFID system. In this Fig. 1, Integrated ZigBee/RFID module reads data from RFID tag and transfers reading data to sensor nodes via UART. And then, sensor nodes broadcast sensing data to base node (sink node) with multihop. Base node communicates to PC via UART. Finally, remote monitoring system displays data communication.

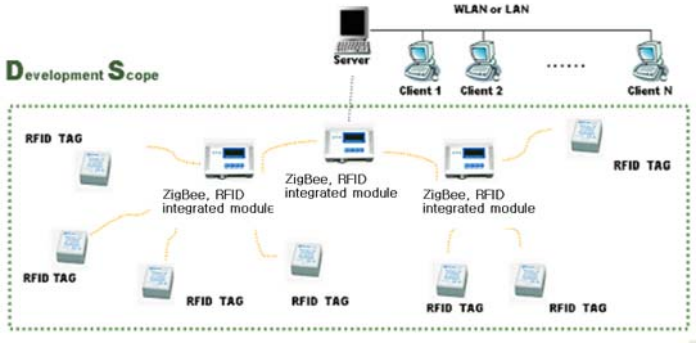

Fig. 1. The Structure of Integrated ZigBee/RFID System.

Following Fig. 2 displays integrated ZigBee/RFID module. Fig 2. consists of two parts in integrated ZigBee/RFID. Left side of Fig. 2 is about the structure of RFID reader and right side of Fig. 2 is about the structure of USN. RFID reader uses 900 MHz, the distance of RFID awareness is 5m, and the distance of USN awareness is 30m. The frequency bandwidth of USN is 2.4GHz, effective awareness or effective distance in USN is 100m. Integrated ZigBee/RFID module recognizes 80 ~ 100 tags at the same time and tags are recognized by USN ad-hoc data transmission.

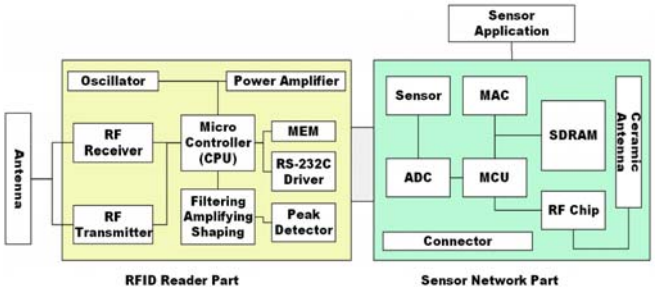

Fig. 2. The Structure of Integrated ZigBee/RFID Reader Module.

2.1.1 Intelligent ZigBee 2.4GHz USN Module

In this paper, we implemented intelligent ZigBee 2.4GHz USN module. This module supports for wireless sensor network based on ubiquitous computing, multi-hop, ad-hoc network solution, and low power communication technology. Also, it supports for intelligent context-aware middleware service and applications on TinyOS. Following Fig. 3 and Fig. 4 display USN module H/W block diagram and the structure of USN module S/W.

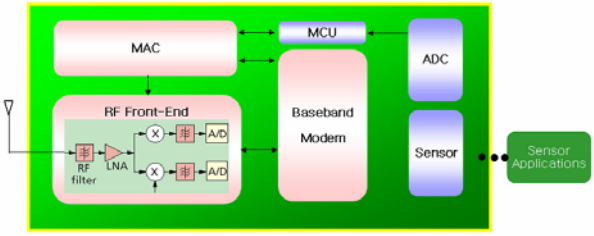

Fig. 3. USN Module H/W Diagram.

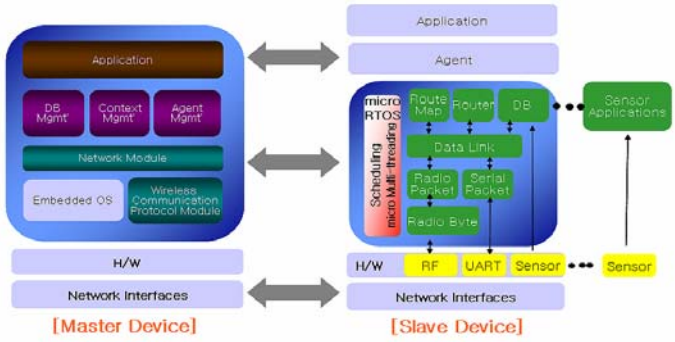

Fig. 4. The Structure of USN Module S/W.

2.1.2 The Implementation of 900MHz RFID Reader Module

Following Fig. 5 shows the structure of RFID reader. RFID reader consists of signal processing part, CPU, and serial interface. RFID signal processing part supports for sending and receiving 900MHz data. It receives tag data from CPU and sends tag data via antenna. The received signal is demodulated via filter in signal processing part and demodulation part. The demodulated data transfers to CPU and then CPU checks if tag data is correct. Also, it checks data when it sends. And, higher layer sends and receives serial data via serial interface.

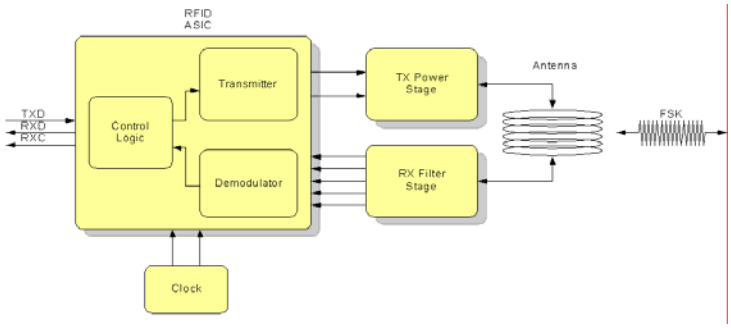

Fig. 5. The Structure of RFID Reader.

2.2 900MHz RFID Reader Protocol

900MHz RFID reader protocol describes data packets about two cases. First case is that USN sends data to RFID reader and second case is that RFID reader sends data to sensor node. There is difference between two packets. First packet has a byte about CMD to indicate commands setting. 60h is for tag type setting, 70h is for single read, and 80h is for continuing read. Second packet has Status field for status indication and Data field is for reading data. When tag setting and configuration is normal, status sends C0h.

When USN sends data to RFID reader, the packet format is following this:

STX	Reader ID	Length	CMD	MODE	Start	End	BCC	ETX

```
- STX: starting protocol 02 (Hex)
- Reader ID : reader's id. 00~0F(Hex). Default value is
00(Hex)
- Length : data length from CMD to BCC
- CMD : setting command
60h : Tag Type, 70h : Single Read, 80h : Continue Read
(Normal Mode)
- Mode : Reading Mode and Tag company (1Byte)
20h : Page unit (8Byte) Reading, 21h : Reserved,
22h : Tag setting, 23h : Reserved, 24h : Tag setting
- Start : Start page or Tag type (1Byte)
01h : Tag - Single Page, 02h : Tag - Multi Page,
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03h : Tag - H4001
- END : Page Length or Tag setting
00h : when Tag is setting
- BCC : 1 Byte, XOR total data without STX
- ETX : protocol type. AB(Hex)
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When RFID reader sends data to sensor node, packet format is following this:

STX	Reader ID	Length	Status	MODE	Start	End	Data	BCC	ETX

```
- STX : starting response protocol. 06(Hex)
- Reader ID : Reader's address. 00~0F(Hex)
- Length : data length from Status to BCC
- Status : status
C0h : Tag setting and Configuration normal,
D0h : sends data normally, F0h : abnormal or unknown tag
- Mode : Reading Mode and Tag type (1Byte)
20h : Page unit (8Byte) Reading, 21h : Reserved,
22h : Tag mode, 23h : Reserved, 24h : Tag mode
- Start : Start page or Tag type (1Byte)
01h : Tag - Single Page, 02h : Tag - Multi Page,
03h : Tag - H4001
- END : Page Length or Tag setting
00h : when Tag is setting
- Data : Reading Data (when Reading Data is existed) to send
as string type
- BCC : 1 Byte, XOR total data without STX
- ETX : protocol type. AB(Hex)
```

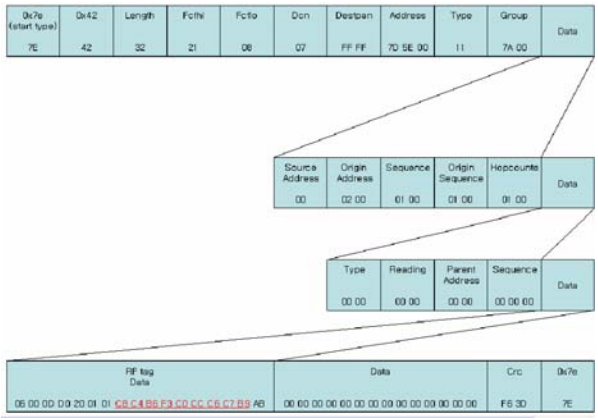

Fig. 6. The Structure of Packet Format.

Above Fig. 6 is packet format. When integrated ZigBee/RFID module receives sensing data, it transfers reading data to base node with following packet format. Header in this packet format is “7e 41 2a 1d 00 00 00 00 00 ff ff 01 7d 5d”.

3 Remote Monitoring System

Following Fig. 7 shows remote monitoring system to display data communication between integrated ZigBee/RFID and tags. It consists of two components. Left component is about tag information and right component is about packet description.

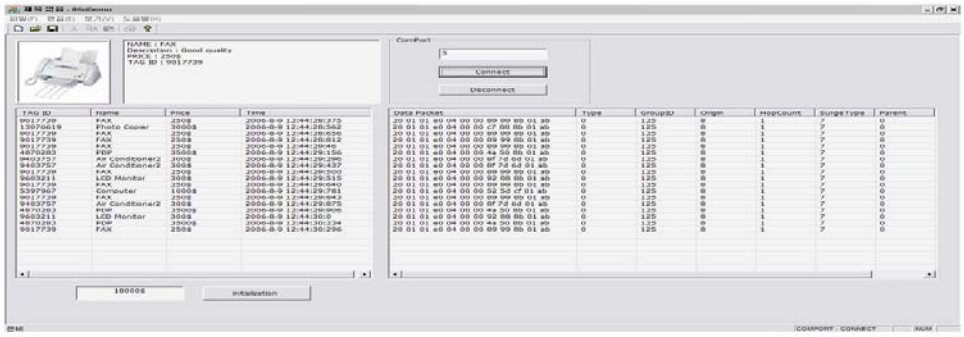

Fig. 7. The Remote Monitoring system.

Left component of remote monitoring system consists of four subcomponents. Left top subcomponent displays image mapped to tag id and right top subcomponent describes tag information. In this case, name is FAX, description is good quality, price is $25, and tag id is 9017739. Middle subcomponent is conflict to right top subcomponent but this information displays cumulated reading tag information so far. Last bottom subcomponent calculates sum of total reading price.

In right component of remote monitoring system, top subcomponent is for connecting network after selecting comport to connect. Bottom subcomponent has seven items such as data packet, type, group id, origin, hop count, surge type, parent. Data Packet field is for peculiar packet contents of each tag. Type field is about Tag type. Group ID field is about networks' group identification and it will be different if many tags try to access and read. Origin field means starting address of many sensor nodes to reach destination. HopCount field means number of sensor nodes to reach destination. In Fig. 7, hop count is 1. It means that origin node directly reached destination, server. SurgeType field means data type. In this case, RFID tag sends data. Finally, Parent field means parent of origin node.

4 Conclusions

We developed intelligent integrated ZigBee/RFID module to combine 2.4 GHz USN to 900 MHz RFID and remote monitoring system. It keeps current RFID functions for wireless sensor network solution, supports sensing function for tags and RFID reader and provides sensor network with ad-hoc. In other words, it is implements to combine "convergence of sensing function convergence" to "intelligent sensor network". Also, we developed remote monitoring system.

We will research efficient algorithm between integrated ZigBee/RFID and tags and develop testbed for integrated ZigBee/RFID to pretest products.

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