The Design and Implementation of Wireless Gateway Using ZigBee Wi-Fi

N. Sunitha, Y. Aruna Suhasini Devi, A. Delip

Abstract: In the present existing system, only Zigbee is used as a wireless communication device to transmit the sensed data to the control room through commercial platform Zigbee. A new system is presented in which the application of WSN (Wireless Sensor Network)/Zigbee is gaining popularity and connecting WSN/Zigbee to the present standard network seamlessly is an important issue. This paper presents the design and realization of a ZigBee-Wi-Fi wireless gateway based on ARM7 LPC2148, ARM9 S3C2440 and embedded Wi-Fi module. In Zigbee network, wireless gateway act as a sink, by receiving data from sensor nodes and interacts with them. In WLAN, wireless gateway communicates with PC or network servers by means of access point. The wireless gateway helps in realizing communication effectively between Zigbee network and WLAN.

Keywords: ARM9 (S3C2400), ARM7 (LPC2148), ZigBee, Wi-Fi Module, Temperature sensor

I. INTRODUCTION

This paper presents a small size, low-power, low-price and lightweight ZigBee Wi-Fi wireless gateway. Wireless sensor network based on ARM7 includes ZigBee module, terminal sensor nodes and route sensor nodes that are responsible for collecting and processing data. A wireless sensor network (WSN) [1] consists of a number of distributed devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration or pressure at different locations. ZigBee [2] is a new IEEE802.15.4 standards-based, short distance, low-data-rate and low-power consumption wireless communication technology.

Different types of Sensors are used to communicate with wireless gateway using Zigbee technology. The wireless gateway based on ARM9 includes Wi-Fi section has 2 operations to perform. It encapsulates the data received from zigbee network in the required format and communicates to wifi module as shown in the figure 2.

The second function of Wi-Fi module is to send data to PC by means of monitoring software through Access Point as shown in the figure 3.

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II. SYSTEM DESCRIPTION

In this project Arm7 LPC2148 is interfaced to sensors like temperature, humidity, pressure, LDR sensors etc., whose data is collected and sent to Zigbee by means of COM1. This data is then received by Zigbee Rx and the received data is sent to Arm9 which may then be displayed on LCD touch screen as shown in fig.2.

The received data is simultaneously displayed on PC by means of embedded Wi-Fi module.

Sensor nodes can be imagined as small computers, extremely basic in terms of their interfaces and their components. They usually consist of a processing unit with limited computational power and limited memory, e.g. MEMS (including specific conditioning circuitry). It is a communication device that has power source in-built, usually in the form of a battery. Other possible inclusions are energy harvesting modules, secondary ASICs, and possibly secondary communication interface (e.g. RS-232 or USB). The base stations are one or more components of the WSN with much more computational energy and communication resources. Sensors act as a gateway between sensor nodes and the end user as they typically forward data from the WSN on to a server.

III. SYSTEM HARDWARE DESIGN

The hardware platform of wireless gateway is made up of two sections as shown in the figure 4 & 5.

![Sensor node section based on ARM7](image1)
![Access point based on ARM9](image2)

The sensor node section consist of Arm7 LPC2148 interfaced to temperature sensor and LDR sensor and sent data is received through Zigbee whose values displayed on LCD screen as shown in fig.4.

3.1. ARM9 S3C2440:

ARM9 S3C2440 is designed to provide hand-held devices for general applications with low-power, and high-performance microcontroller solutions in small die size. To reduce total system cost, the S3C2440A includes the following components. The S3C2440A is developed with ARM920T core, 0.13um CMOS standard cells and a memory complier. Its low-power, simple, elegant and fully static design is particularly suitable for low cost- and power-sensitive applications. It adopts a new bus architecture known as Advanced Micro controller Bus Architecture (AMBA). The S3C2440A offers outstanding features with its CPU core, a 16/32-bit ARM920T RISC processor designed by Advanced RISC Machines, Ltd. The ARM920T implements MMU, AMBA BUS, and Harvard cache architecture with separate 16KB instruction and 16KB data caches, each with an 8-word line length.

3.2. ARM7 LPC2148:

The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty.

3.3. EMW-380 Wi-Fi Module:

The wireless gateway adopts EMW-380 Wi-Fi module [10] to realize the WLAN capabilities. It is an embedded Wi-Fi (802.11b/g) applicable module. The hardware is composed of ARM processor and Wi-Fi RF chip. The software integrates some network protocols such as Wi-Fi, TCP/IP, UDP, and DHCP. The module provides an SPI/UART interface to connect with MCU. A simple API command set is provided to implement link layer data services based on 802.3 frame formats. The module supports AP and Ad-Hoc, RF channel automatic choice and WEP encryption, which is suitable for small system with standard Wi-Fi access.

3.4. Zigbee:

ZigBee is a specification for a suite of high level communication protocols used to create personal area networks built from small, low-power digital radios. ZigBee is based on an IEEE 802.15 standard. Though low-powered, ZigBee devices often transmit data over longer distances by passing data through intermediate devices to reach more distant ones, creating a mesh network; i.e., a network with no centralized control or high-power transmitter/receiver able to reach all of the networked devices. The de-centralized nature of such wireless ad-hoc networks make them suitable for applications where a central node can’t be relied upon.

IV. SYSTEM SOFTWARE DESIGN

The software architecture of the wireless gateway includes system control, software design of EMW-380 Wi-Fi module, software design of ARM9 and wireless gateway application layer protocol. The software architecture is...
shown in Fig 6. System control regulates hardware and application layer protocol of the wireless gateway.

Figure 6: The software architecture of wireless gateway

A. EMW-380 Wi-Fi Module Software Design:
EMW-380 Wi-Fi module communicates with STM32W108 through UART and EMSP protocol. The EMSP protocol has nothing to do with the physical connection. The module has two operative modes: configuration mode and data transparent transmission mode. In the configuration mode, all the work is controlled by EMSP command. In the data transparent transmission mode, the module encapsulates the received data into TCP/UDP packets and sends them to remote end. Furthermore, it can send the TCP/UDP packets that come from remote end to STM32W108. It contains a protocol head (8 Bytes) and data field (maximum is 256 Bytes). The EMSP protocol consists of 12 commands to implement module control, network control and network communication. They are

EMSP_CMD_RESET,
EMSP_CMD_START,
EMSP_CMD_GET_CONFIG,
EMSP_CMD_SET_CONFIG,
EMSP_CMD_GET_STATUS,
EMSP_CMD_RECV_DATA,
EMSP_CMD_SEND_DATA,
EMSP_CMD_SCAN_AP.

B. Data from ZigBee network to WLAN:
In the ZigBee network, after establishing a network by wireless gateway, sensor nodes join in the network within the time that wireless gateway permits. When the time expires, sensor nodes can’t join in the network anymore unless the button is pressed on route sensor nodes and then the permit joining flag becomes TRUE again. But if the sensor node is the terminal node, it can’t allow other nodes to join in the network through itself. So the size of the network can be dynamically changed, and the extensibility of ZigBee network is good. Every node has a unique Node ID assigned by wireless gateway once join process has completed. After interacting with wireless gateway, sensor nodes begin to send data to wireless gateway.

V. SYSTEM IMPLEMENTATION AND PERFORMANCE EVALUATION

Hardware test environment includes wireless gateway, Zigbee based ARM7 which includes several sensor nodes like temperature sensor & LDR sensor, PC, network sniffer produced by Mxchip Company as shown in the figure-8 and a network protocol analyzer for UNIX and Windows called Wireshark. Temperature and LDR sensors inputs are given to this system for analysis.

Initially ARM7 configures for the sensor nodes which are interfaced to it as shown in the figure 7(a). Sensor nodes collect and process the data to the Access point through ZigBee. At the Access point section the function of wireless gateway is tested & initialization of Wi-Fi module takes place as shown in the figure 7(b).

Figure 7 (a)  Figure 7(b)
Figure 7: (a) Configuration of sensor & the ZigBee at the Node section (b) Initialization of Wi-Fi

EMW-380 Wi-Fi Module is configured to the ARM9 & to the PC using the MxChip software which acts like a PC suit to the EMW-380 Wi-Fi module as shown in the figure 8 and network is analyzed at the monitoring PC using Wireshark Software.

Figure 8: Configuring the EMW-380 Wi-Fi Module to the ARM9 & PC

At the access point ARM9 includes Wi-Fi section which encapsulates the data that received from different nodes through ZigBee network according to a certain format and transmits them to Wi-Fi module as shown in the figure 9.

Figure 9: Monitoring of the Temperature statues including Date & time at Node & Access Point Section
Data packet is sent to wireless gateway only if the IP address matches with that of wifi module using Wireshark software and it capture the data packet that wireless gateway sent to monitoring software as shown in fig10.

**Figure 10: Monitoring the status of the Sensors in the PC through Wi-Fi**

**VI. CONCLUSION**

In this paper, the ZigBee Wi-Fi wireless gateway based on ARM7, ARM9 and EMW-380 Wi-Fi module can connect the ZigBee network to standard network seamlessly. From the result of performance test it is observed that the performance and stability of wireless gateway suits the usual target of WSN application, which is low real time demand, small amount of data transmission and low bandwidth. As WSN applications expand further research can focus on the low power design of wireless gateway, using wireless gateway ID to identify different deployment environments and adopting embedded Web Server technology enables users to visit different WSNs information.

**REFERENCES**