

## General Purpose Embedded Systems Using Linux and Wireless Protocols

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**Abstract**-This paper introduces the design and implementation of a Wi-Fi wireless meter reading system. The design of management software and wireless terminal including hardware and embedded software are introduced in detail. ARM9 and Linux are adopted for the implementation of wireless terminal. The communication between wireless terminal and management software is realized by the program based on Winsock. Access2003 is used for the storage of information. Smart Message Language (SML Protocol) is used to design the data structure aiming to make data communication maximally simple and suitable for implementation in low-power embedded systems and solve the communication problem between different equipment. A Wi-Fi network experiment system including a intelligent meter, a wireless terminal, an access point and the management software is constructed to test the performance of the wireless meter reading system and the result shows that the meter data can be correctly received and updated every two seconds which indicates that the system has good communication performance and reaches the purpose of meter reading, efficiently solving the low safety and efficiency problems of traditional meter reading.

**Key words:** Wireless Terminal • Management Software • Smart Message Language • Data Structure

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### INTRODUCTION

Wireless Meter Reading is a process that the meter data is read and processed automatically via special equipment using wireless communication and computer network technology. Compared with the traditional meter reading, it not only effectively saves human resources but also save the wiring cost and helps the management department find problems in time and take appropriate measures to deal with [1, 2]. WI-FI, the wireless communication technology used in this system is also called 802.11 standards and has the advantages of high transmission rate, convenient networking, bestrow scope, strong anti-interference capability and low price. Wi-Fi network construction cost is lower than that of traditional LAN, requiring the installation of a certain number of wireless Access Point to satisfy the signal coverage of designated area [3]. The main part of the design of the system is the management software and WI-FI wireless terminal including the hardware and embedded software. One of the most important problems of wireless meter reading is that products of manufactures are lack of interoperability, so it is necessary to define a unified data

structure and protocol for communication. Smart Message Language (SML), a German national standard, is created against the background of drawing up a specification that lays down a communication protocol for applications in the environment of data procurement and equipment parameterization. SML is used in this system for the design of data structure in the communication between Wi-Fi wireless terminal and management software.

The outline of the paper is as follows. The overall structure is described in section 2. The design of the wireless terminal is described in details in section 3. In section 4 and section 5, the design of data structure based on SML and management software is given. Section 6 gives the experimental results and analysis. Conclusions are summarized in section 7.

**The Overall Structure:** The Wireless Meter Reading System based on WI-FI communication technology is made up of Intelligent Meter, Wireless Terminal, Wireless Repeater, Access Point and Control Center. Figure 1 illustrates the overall structure of the system. The system can be divided into three main parts: Intelligent meter, Control Center and WI-FI Wireless Network which is

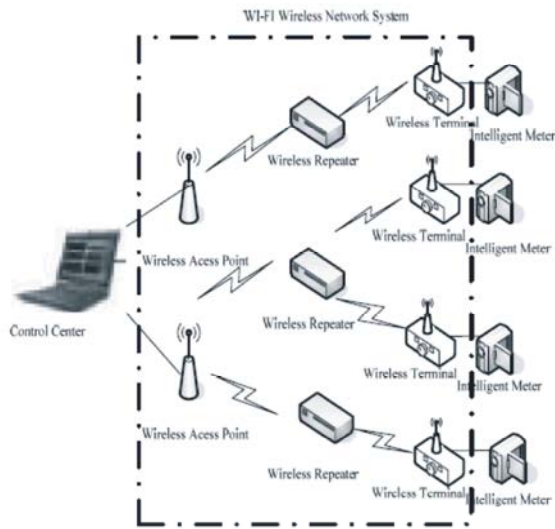


Fig. 1: Meter Reading Systems Architecture

made up of Wireless AP, Wireless Repeater and Wireless Terminal. The WI-FI wireless terminal which is connected to intelligent Meter by RS485 collects the information of the intelligent meter via Modbus/TCP protocol. The data is then sent to the Access Point after being processed. The communication between Access Point and control center is via TCP/IP protocol. The access point sends the data to the control center where the data is processed and stored into the database. Users can get the information by using the management software which is the core of control center. Control Center sends command such as data procurement, data storage, alarming and so on to control the whole system [4].

The function of each part of the system is as follows: The main function of wireless terminal is connecting the intelligent meter and the WI-FI Wireless LAN, transmitting the meter data and information to the Wireless LAN and receiving commands. To guarantee the communication quality and rate, the communication rate is set to 100kpbs and the size of data is limited to 512byte/point. The system specifications are described in details in Table 2. Considering the privacy and security, WPA and Address Code Check is used.

### The Design of Wireless Terminal

**The Design of Hardware:** The WI-FI wireless terminal communicates with the intelligent Meter by RS485 interface and sends data to wireless access point. The hardware mainly includes core processor, power supply circuit, Wi-Fi wireless module, storage unit, LED indicator light, reset circuit, RS485 interface and ethernet interface. The hardware structure is illustrated in Figure 2.

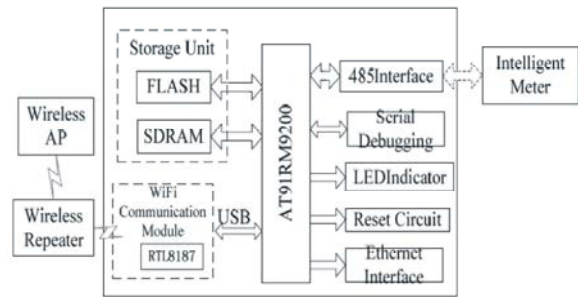


Fig. 2: Hardware Structure Diagram

AT91RM9200 processor of Atmel Company is used for the core processor. AT91RM9200 microprocessor enlarges the SDRAM memory and FLASH memory outside. SDRAM memory stores the program running code and FLASH memory stores data that is collected. When the task is running, the program code from FLASH memory will be copied to the SDRAM memory for operation and this can improve the speed of the system. The reset circuit is made up of hardware reset circuit and software reset circuit. Hardware reset circuit uses IMP811S chip which can ensure the reliable reset while software reset circuit adopts the most simple RC reset circuit which is mainly used to restore initial set. Serial interface is mainly used for debug [5].

Power supply system is the key of the device and it is the basic guarantee of the stable operation of the system. This system adopts the regulated 24V DC source. Power supply module adopts 24S05-6W isolation power module whose input voltage is 18 - to 36VDC and output voltage is 5VDC. 5V voltage is converted to 3.3V by 1117M-3.3.

Wi-Fi wireless module adopts G-SKY wireless transmitting module whose transmitting chip is RTL8187 chip of REALTEK Company. TL8187 chip uses IEEE802.11g<sup>draft2.0</sup> standard and can be compatible well with IEEE802.11g/IEEE802.11b standard. USB2.0 physical layer is integrated in this module which can be connected to the core processor directly through USB interface. It has the advantages of reducing the blind spots of the coverage of the area and expanding the coverage of wireless signals effectively which makes it a low cost and high level of integration wireless module.

**The Design of Embedded Software:** The design of wireless terminal software mainly includes three parts: the transplantation of operating system, the transplantation of Wi-Fi wireless module drive and the design of application.

**Operating System Transplantation:** Wi-Fi wireless terminal uses Linux2.6 as operating system. Linux has the features of widely hardware support which means it can run on every popular CPU. It also has the advantages of perfect network communication and file management mechanism, open source and efficient real-time kernel cutting. Operating system transplantation includes loader (Bootloader), the kernel cutting, configuration and compile and root file system transplantation. Guide loader is in charge of the target boards initialization when powered up, loading kernel to memory, transferring guide parameters to kernel and operating kernel. The kernel cutting and configuration must ensure system functions firstly and ensure the normal operation of every hardware circuit including the use of I/O port and the drive of serial port, USB and Wi-Fi wireless module. “Make menuconfig” is used to configure the kernel and add the support of the file system Ramdisk, module loading and unloading, network optimization, PCMCIA bus and some basic equipment driver support. After the configuration, “make uImage” command can be used to compile to generate ‘uImage’ files which are cross compiled to generate binary files. The binary files are compressed by zip and then translated to identifiable ‘uImage’ such as U-Boot which then can be download to hardware platform to run. Considering that AT91RM9200 platform only neither has “NOR Flash”, the root file system adopts JSSF2 file system which is developed for flash and have permanent features. The bin/,dev/,etc./lib/,proc/,sbin and /usr of root file system is necessary while others can be adjusted according to the requirements. Considering the partition uses of NFS file system and NOR Flash need hard points, /mnt directory is kept and var directory is used to store temporary data and root directory stores some root user configuration files and tmp directory stores temporary files [6].

**Transplantation of Wi-Fi Wireless Module:** Wi-Fi wireless module uses RTL8187L module of Realtek [7]. Linux-2.6.32.2 kernel provides the drive support of RTL8187 and RTL8187B wireless module, but this dive dose not perform well on RTL8187L wireless module and the function support is not perfect [8]. At the same time, Realtek official provides the support of Linux of this wireless module and RTL8187L driver source code, making the support of RTL8187L more perfect. As a result, drive provided by Realtek official is used and only needs some modification [9]. RTL8187L driver source code is downloaded and rtl8187 and ieee80211 files are copied to driver/net/wireless. Makefile and Kconfig file is modified making it added to kernel and compiled.

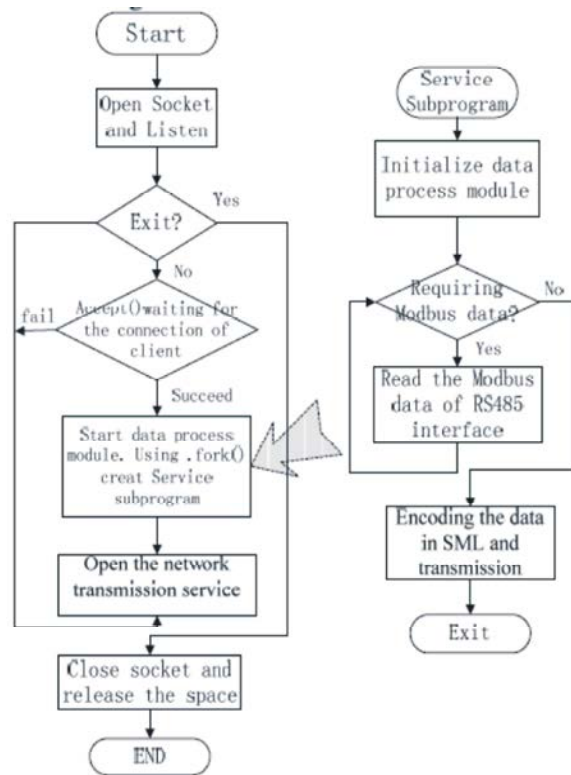


Fig. 4: Flowchart of application Program

Add “obj-\$(CONFIG\_RTL8187L)+= rtl8187/” to “driver/net/wireless/Makefile” file and add “config RTL8187L” and “tristate “Realtek 8187L USB support”” to “driver/net/wireless/Kconfig” file. New “Makefile” file under “drivers/net/wireless/rtl8187” directory and add compiler marks and target file of core program of RTL8187L drive to it. IEEE802.11 protocol support must also be added and configuration module is named “RTL8187L”, the same as that of Kconfig. Configuring RTL8187 drive by “Make menuconfig” and compiling to generate .ko module file by “make module” and downloading .ko drive program to hardware platform can support the operation of Wi-Fi module very well [10].

**The Design of Application:** The design of application mainly includes network communication and RS485 communication. TCP/IP is used in the network communication and data structure is designed based on SML which will be introduced in section 4. Socket is used for network programming. Open the socket first and initialize it to data stream socket and listen to it. Accept () function then waits for the connection of the client. If the connection is successful, the data will be sent. The flowchart of the program is illustrated in Figure 4 [11].

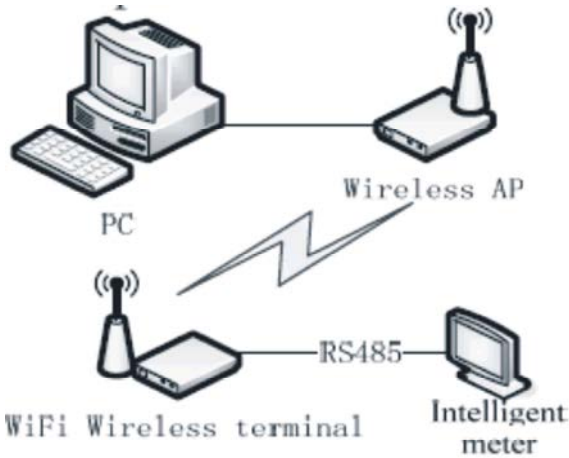


Fig. 8: Experiment System

**Experimental Result and Analysis:** In order to test the communication performance of the system, network experiment system as Figure 8 shows is used. The equipment's are PC, wireless AP TL-WA501G+, wireless Wi-Fi terminal and intelligent meter. Open management software and configuration the wireless access point and the open the DHCP dynamic IP service functions, the IP of Wi-Fi terminal finally got is 192.168.1.101. The IP of management software is 192.168.1.101 and the port is 4000. The data can be received after the server being connected. The data is shown in Figure 9 [12]. The voltage that the meter connected to fluctuates in a small scope around 220V and is the same as meter data. Embedded software and management software runs normally and the data acquisition module and network communication module are reaching the requirements.

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