A High-Speed Wireless Transmission Scheme for Wireless Sensor Network

Li Ma, Hui Wu

College of Information Engineering, North China University of Technology
Beijing, 100144, China
Email: mali@ncut.edu.cn

Abstract
Along with more extensive application of wireless sensor network (WSN) technology, real-time and a large amount of data transmission requires WSN system to achieve high-speed transmission. Therefore, a high-speed wireless data transmission scheme is an essential requirement in WSN environment. We propose a modified WiFi (Wireless Fidelity) protocol for wireless transmission and high speed serial peripheral interface, and design a single-node system to test the scheme. The experimental result shows that the average transmission rate of the system can reach 893.1kb/s, meet the demand for high-speed wireless transmission.

Keywords: High-Speed Transmission, Wireless Network, GS1011

1. Introduction

Wireless sensor network (WSN) integrates technologies of sensor network, embedded computing, and distributed processing of information, modern wireless communication, for information collection, transmission, and management in an integrated, intelligent information system [1-3]. At present, many researches focus on the micro-nodes energy-constrained in wireless sensor networks. They can handle real-time data and relatively easy data in some scenes, such as monitoring temperature, pressure and humidity in the environment. Also, WSN has been used for the transmission and processing of single multimedia information [4], such as audio, images. Usually, the information is transmitted by the low bandwidth and tolerable delay. However, with the complex variability scenes of the monitoring requirement, these scalar data [5] have been unable to meet the full demand of the people for environmental monitoring and a more widely range of applications, such as emergency video surveillance and military battlefield real-time monitoring [6]. These scenes require informative image, audio, video timely wireless transmission to meet the fine-grained and accurate information monitoring requirements [7]. There is a research on Multimedia Wireless Sensor Network with High-speed multi-hop AMCP (Asynchronous Multi-channel Coordination Protocol) algorithm [8] that can support multi-channel and provide high-speed bandwidth [9]. To ensure the transmission quality and real-time for multimedia data, the high transmission speed is a significant influence factor. Therefore, the high speed transmission scheme can ensure the effective quality of the multimedia data real time transmission in the WSN environment. In this context, high-speed wireless transmission scheme includes high speed wireless protocol and high rate transmission interface, which plays a hugely crucial role in practical applications.

2. The overall design of scheme

A high-speed wireless transmission system in the WSN environment is designed to implement high-speed and real-time transmission of multimedia information in this paper. First, sensor nodes in the monitoring scene collect data and transmit the information to sink node via wireless. Then, data information is transmitted to the monitoring center via Wi-Fi. Finally, related application software in the monitoring center will be used for data analysis and management, such as data display, data storage and query processing.

Meanwhile, the user can send commands to the remote nodes to control their states. The whole wireless transmission network is established based on Wi-Fi. Data acquisition module connects with wireless transceiver module through a high speed serial interface internal the node. The overall system framework is shown in Figure 1.
3. System design

In this paper, high rate transmission scheme mainly embodies in the high rate radio transmission standard and high rate connection interface. Accordingly, we design a high-rate wireless transmission system. The data acquisition node composes of a GS1011 module designed for the Internet of Things by GainSpan Company and idea6410 platform, which is connected via the high speed serial interface. The nodes access internet through WiFi, then send data to the monitoring center.

3.1. Transmission technology in WSN

In wireless sensor network, transmission technology mainly uses a short-range wireless communication protocol, such as ZigBee protocol or WiFi [10]. Nowadays, ZigBee protocol is widely used in WSN system. However, its low transfer rate limits the application of a large amount of data real-time transmission. For comprehensive perception application requirement, it needs to use a high-speed transport protocol in the WSN system, such as WiFi protocol.

ZigBee is a group of wireless standard based on the IEEE 802.15.4, an economical, efficient, low complexity, low power and low rate wireless technology, works in the 2.4GHz or 868/928MHz. Their data transfer rate respectively is up to 250kbps, 40kbps and 20kbps. With low power consumption and low cost, ZigBee technology has an extremely wide range of applications, especially in the large-scale deployment and low rate application occasion. But some of the limitations of the ZigBee protocol, such as a lower transmission rate (maximum 250kb/s), the small coverage (10-100m), make it not suitable for high-quality video transmission occasion which requires high bandwidth and real-time. Therefore, in this context, the high-speed wireless transmission technology WiFi becomes the ideal choice.

WiFi is a short-range wireless transmission technology similar to ZigBee, supports for internet access through radio signals in the range of a few hundred meters, up to 300m in the vast outdoor. WiFi technology is characterized by high transmission speed, the maximum speed up to 54Mbps. The bandwidth can be automatically adjusted. In the case of interference or weak signals, the bandwidth can be adjustable to 1Mbps, 2Mbps, 5.5Mbps and 11Mbps. Comparing with ZigBee-based wireless sensor network, WiFi wireless sensor network has some advantages: high-bandwidth, large coverage area, non-line-of-sight transmission, easy expansion, strong robustness and small disturbance of links [11]. Meanwhile, with using of sleep-wake or energy capture technology, energy consumption problem has been effectively resolved.

3.2. Connection interface of data acquisition node module

WiFi module universally connects to microprocessor with USB, SDIO or serial interface. The USB or SDIO way is characterized by fast, but relatively complex for hardware and software design.
Compared to the serial interface, the energy consumption is also higher[12]. The serial interface is a universal and integrated in the vast majority of microprocessors. Using the serial interface to connect control module and the various functional modules, software design of the microprocessor is relatively easy and at the same time the transfer speed theoretically can reach 10Mb/s[13]. This speed can meet the requirements of the system.

The data acquisition module is connected to the transmission module by high-speed serial interface SPI (Serial Peripheral Interface) to construct a sensor node. The serial interface is an internal integrated interface of GS1011 and idea6410. Therefore, it is easy to construct the node and the sensor node enables WiFi capability simple and fast to achieve high-speed wireless transmission in wireless sensor networks. The connecting scheme is able to shorten the development cycle. The hardware platform of sensor node is shown in Figure 2. It is a block diagram of main portions of a node.

![Figure 2. Node hardware block diagram](image)

Both ends of serial port (SPI bus) are the master Idea6410 platform and the slave GS1011 module. The master controller and the slave processor connect through MISO, MOSI, SS and SCK signal lines of SPI. In addition, CALL (slave call signal) [14] pin must also be allocated from the normal I/O of the host controller. The pin is connected to the slave processor in order to receive the call signal from slave processor. CALL signal is added based on the standard SPI protocol. According to the SPI bus, only the host can send data to the slave machine at any time, and a slave processor cannot take the initiative to transfer data to the host controller. So CALL signal is added between slave processor and the host controller. The master-slave machine communication process can achieve two hardware handshakes, so as to solve the problem that the slave GS1011 module cannot actively send data to the host. Therefore, the server side can facilitate to send control information the end nodes.

3.3. GS1011 module and idea6410 features

GS1011 module is a highly integrated, ultra-low-power WiFi wireless system-on-chip. It consists of two pieces of ARM7 processor, one of which is an application processor, integrated within the Flash and SRAM memory, external expansion 2 ADC, SPI, and GPIO interface, used to receive analog and digital information from sensors. Another processor integrated 802.11b/g MAC/PHY layer is mainly responsible for the wireless data transceiver and supports IEEE802.11b/g/n protocol stack. The GS1011 module only relies on one AA battery to run for up to 10-year-old by effective active/standby state transition mode, the system power management, compact pin design, real-time operating system, and the clock control wake-up function. So GS1011 module is an ultra-low-power Wi-Fi sensor network solution. GS1011 module can process data, complete WiFi transceiver function. When the end node does not process the audio and video data, GS1011 module can be a single node that achieves scalar data collecting and transmitting. Idea6410 core-board is S3C6410, which takes advantage of ARM1176JFZ-S core eight level streamlined lines and can run at a high CPU clock speed up to 667MHz. The chip has strong internal resources and video processing capabilities. In order to reduce the burden on the bandwidth and power consumption, idea6410 compresses the multimedia data to transfer, after the node captures the audio and video data.

3.4. Software design

The system software includes three parts: on the idea6410, the program implements functions of data acquisition, processing and transmission to the GS1011 module through the serial port. On the
GS1011 module, the program establishes a network connection, sends data received from idea6410 to the server via WiFi, and forwards control information of the server. On the server, the program receives and displays data gathered by nodes, as well as transmits control information.

Idea6410 carries Wince6.0 Operate System, on which the application is developed with VS2005 integrated environment. The GS1011 module equips with an uVelOSity real-time embedded system of the Green Hills Company, using integrated development environment MULTI to develop an application. On the server, the program is based on the VS2005 development in Windows XP. After the system starts up on the end node, idea6410 development board program sends AT commands to GS1011 module to complete network configuration and make the node establish a network connection with the server with TCP way. The flow chart is shown in Figure 3. After the network connection is finished, the data are sent from the serial port to the GS1011 module by a specific packet format (see Table 1). When parsing data packet, the 'ESC' indicates actual data start and 'Z' means reading the block data in length of data to avoid the 'ESC' character in the actual data causing a parse error, "length" means the length of the actual data.

<table>
<thead>
<tr>
<th>Actual data flag</th>
<th>Analytical way</th>
<th>Length</th>
<th>Data content</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC (1BH)</td>
<td>Z (5AH)</td>
<td>Length of actual data</td>
<td>Actual data</td>
</tr>
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</table>

![Table 1. Data packet format](image)

After the system startups, GS1011 module can complete network connection by default setting parameters or receive AT command from the idea6410 to realize network configuration. Then it parses the data to obtain the actual data sent to the server. The program flow is shown in Figure 4.
Server-side program runs on a PC, initializes the network configuration and listens for the connection of the end node. After establishing a connection with the terminal node, the server can communicate with the terminal node, control the terminal node, and parse the data received from the idea6410, and then store and display the effective data. The program flow is shown in Figure 5.
4. Test results

In a laboratory environment, the GS1011 connects laboratory wireless router, obtains IP address and uses the C/S mode to establish socket communications with the server. On idea6410 development board, send 10M, 50M, 100M audio and video files to the server. Several times tests show that the size of the files the server receives is consistent with the size of the source files, and can play normally. It indicates that data transmission is reliable. Record file size and transmission time. The experimental results are shown in Figure 6. The average transmission rate of the file is 893.1kb/s.

Taking into account the lowest transmission rate of the video for the human eye, the transmission rate \( v \) is calculated in accordance with the following formula:

\[
v = m \times n \times p \times \mu
\]  

Which \( m \times n \) represents the display resolution; \( p \) is the minimum number of frames transmission per second; \( \mu \) is the compression ratio for the transmission of images. In the experiment, idea6410 has a 4.3-inch LCD screen with a resolution of 480×272 pixels. The video image needs 25 frames per second for human to watch normally. In order to ensure video quality, compression ratio takes 10:1 [15]. Therefore, the lowest transmission rate is 326.4kb/s that can satisfy the video playback in the server. The transmission rate of proposed scheme is far more than the minimum transmission rate of requirement.

![Figure 6. Test results of different size file](image.png)

5. Conclusion

This paper proposes a high speed transmission scheme in wireless sensor network. The scheme can complete large amount data real-time transmission, such as multimedia video data. In such a scheme, data acquisition node is composed by idea6410 platform and the lowest power consumption GS1011 WiFi module. Idea6410 platform is connected to GS1011 module through the high speed serial interface. The scheme has characteristics of high speed, low power consumption and easy to implement.

With the further application and deployment of wireless sensor network, high-speed data transmission is essential to ensure data quality in the real-time multimedia data acquisition and transmission. Wireless sensor network with high-speed transmission has significant practical significance in fields of visual battlefield surveillance, security monitoring, traffic monitoring, smart home and health. A high-speed wireless transmission data collection node is designed and implemented.
in this article. Test results show that the system can satisfy the demand for multimedia transmission. It has considerable value both in research and practice application.

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Reference