The Research and Design on TDD Voice WSN

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Abstract: A Time Division Duplex(TDD) approach is demonstrated for voice communication in the environment of wireless sensor networks. The architecture of the Voice Wireless Sensor Networks (VoWSN) is presented and the hardware designing of Voice Node and Gateway Node are described in detail. Voice quality of different scenarios such as indoor, corridor, corner and outdoor are tested. It is resulted that good voice quality can be obtained in short distance or line of sight with no obstacle. The Routing Node and Gateway Node is introduced to relay in the case of long distance or with obstacles in the channel path.

Keywords: Wireless Sensor Networks, Time Division Duplex, Voice Communication

I. INTRODUCTION

Wireless Sensor Networks (WSN) is widely used in Environmental Monitoring, industrial and agricultural production, military probe and so on. In recently years, with the development of multimedia communications technology, audio sensor networks is applied to transmit short distance audio signals for target locating and tracking.[1-6]

R. Alesii, F researched the problems related to the transport of an audio signal through a wireless channel and sensor nodes and presented a project for an audio surveillance system in reference [6].

In many researches for acoustic locating and tracking, the audio signal transmission way is simplex[7-10] With the widely application of modern mobile communication, low cost short distance voice communication is rarely focused on.

A new approach for short distance voice call can be contributed by using wireless sensor networks. The voice call system using WSN is called Voice WSN (VoWSN)[6]. In some circumstance, the voice WSN is widely needed, such as medical emergency call. Comparing to traditional medical emergency call system, VoWSN have many outstanding advantages in functional completeness, mobility, flexibility, cost and construction period.

Usually, there are two duplex way for short distance wireless communications: Frequency Division Duplex (FDD) and Time Division Duplex (TDD). The Structure of FDD is simple, but more frequency resources are required. The frame structure of TDD is complex, but frequency band are saved. More node capacity can be provide by TDD since the frequency is limited.

II. NETWORK ARCHITECTURE

The Voice WSN we designed is consisted of voice node (or handheld node, refined node), routing node(or reduced node), gateway node and call center. The network topology is constructed by ZigBee protocol. The voice node includes voice module, ZigBee wireless communication module, microphone and headphones(or speaker). The routing function is executed only by the routing node when the distance of the both speakers is too long to guarantee the QoS, since only the wireless communication module is contained. When one subnet of Voice WSN is far away from an other subnet, the gateway node can be used to connect both sides of speaking. A CDMA module and a ZigBee module is integrated in the gateway node. The call center is designed to deal with communications between voice nodes, to display and store the calling voice nodes information and call information. Figure 1 shows the architecture of wireless sensor network for voice call.

![Figure 1 Architecture of Wireless Sensor Network for Voice Communication](image)

III. HARDWARE DESIGN

A. Voice Node

The voice node is consisted of voice circuit, digital signal processing circuit, ZigBee module, power, buttons and status indicators. The structure and composition of voice node is shown in Figure 2.
The Voice analog signal amplification, filtering, acquisition, quantization, encoding and decoding, A/D and D/A conversion and power amplification are completed in the voice signal process circuit.

And the main function of digital signal processor circuit is to complete real-time voice digital signal processing including ADPCM encoding to reduce data rate and interleaving to resist to wireless channel fading.

The ZigBee chip CC2430 as wireless communication MCU, antenna and other circuit components are contained in ZigBee module. The function of node circuit control, wireless data transmission and receive is accomplished by the ZigBee module.

The supply of analog power of 3.3V, digital power of 3.3V and 1.8V is supported by the power module. Figure 3 is the photo of voice node hardware circuit.

B. Routing node

The routing node is function reduced as showing in Figure 4, only consisting of ZigBee wireless communication module and power supply.

C. Gateway node

Gateway node is consisted of ZigBee module, CDMA module, ARM processing circuit and power circuit. The structure of gateway node is shown in the figure 5. The ZigBee networks and CDMA networks is connected by the gateway node.

The ZigBee module in gateway node, voice node and routing node is identical. The module of Huawei EM200 is used as CDMA module in gateway node to provide CDMA 2000-1X wireless communication. The TCP/IP protocol stack is embedded in EM200 to facilitate data transmission, data transfer. The ARM7 TDM-STM core 32/16-bit embedded processor chip of LPC2132 is used as the MCU of Gateway node, which with rich interfaces and simple peripheral circuits. Two voltage of 4.2V and 3.3V power output are provided to the CDMA module, ZigBee module and ARM processor.

IV. VOICE SIGNAL PROCESSING AND ENCODING

Voice signal processing and source coding are needed to complete the wireless voice communication in the voice node. Waveform coding, parametric coding and hybrid coding are the mainly used audio source coding method. The voice quality of waveform coding is better and the algorithm complexity of it is lower than the other two. The coding rate of waveform coding method Adaptive Differential Pulse Code (ADPCM) is 32kb/s. With the same voice quality, the rate of Pulse Code Modulation (PCM) is 64kb/s. Though the compression rate of parameter coding is relatively high, but with poor voice quality and higher complexity which requires higher processor performance. The dedicated vocoder is usually used for designing parameter coding circuit. Which would greatly increase the cost and difficulty for future updating. The analog voice is digitalized at the first step. Then, before the data transmission, the 16bit digital voice signal is processed in turn through the order of ADPCM coding, voice buffering, interleaving, data buffering. In the end of receiver,
the inverse steps are executed as shown in the figure 6.

Figure 6 Voice Signal Processing and Coding

V. TDD

Time Division Duplex (TDD) is one duplex mode of communication system and is used to separate uplink and downlink in wireless communications. The same frequency but different time slots are used in TDD wireless communication system for data sending and receiving. Two symmetrical frequency channels are needed for the uplink and downlink of frequency division duplex (FDD) wireless communication system. Thus, The frequency resources are saved of TDD system in contrast to the FDD system. Then, more node capacity can be provided by using TDD.

In TDD wireless communication system, time slots are divided two parts: uplink slot and downlink slot. Different slots are assigned to the transmitter and the receiver to realize the time division duplex communication. The data transmitting and receiving of FDD are shown in Figure 7 and Figure 8 respectively.

VI. TESTING

Power switch, call and hang up buttons are shown in Figure 9 as operational key of voice node. Microphone interface, headphone jack, power connector and the wireless T/R interface is designed to interface outside components.

Figure 9 Voice Node

The voice quality of our VoWSN in different scenarios such as outdoor, indoor, corridor and corner are tested. Figure 10-13 are the testing photos.
As shown in the above table of testing results, voice quality is dropping with the increasing communication distance, or with obstacles in the channel path. In order to solve this problem, the routing node and gateway node will be introduced to relay.

VII. CONCLUSION

In this paper, the time division duplex(TDD) method is applied to achieve duplex voice communications in wireless sensor networks environment. The designing of voice node and gateway node are subscribed in detail. The source coding method of ADPCM is used by voice code. To against the burst fading of wireless channel, the interleaving is introduced. The voice quality of different scenarios are tested. Good voice quality is obtained in short distance or line of sight with no obstacle. Routing node and gateway node can be used to relay in the case of long distance or with obstacles in the channel path.