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Short-Range Wireless Voice Call System Based on Mobile Ad-hoc Networks

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Abstract— Currently, there are several short-range wireless communication technologies such as Bluetooth, ZigBee, but they are not suitable for voice call because of their short distance or low ratio of transportation. In this paper, we proposed and realized a short-range wireless voice call system based on mobile Ad-hoc network. In order to solve how to create the directly connection in case of the callee's Wi-Fi is closed, we'll send a kind of special SMS which acts as a signal to certain port to open the callee's Wi-Fi, and then use the APIs provided by the mobile phone's OS, the directly connection can be easily created which the voice call based on. Besides this realization of one-hop connection, we also analyzed the situation of multi-hops connection. In a typical experimental environment which is composed of multi-hops and multi-nodes, we verified the feasibility and effectiveness of our approach.

Keywords*:* Ah-hoc network, Wireless voice call, Multi-hops, Mobile phone

1. INTRODUCTION

In recent years, with the rapid development of micro electric, network and communication technology, the wireless communication has made a broad application prospect in many fields because of its low cost, the nimble networking, and few limits from the environment [10]. And currently, most of the wireless communications are based on Bluetooth or ZigBee technology, especially in mobile phone, there are so many applications base on Bluetooth, for example, we can send our files via Bluetooth. But the transmission distance of Bluetooth is so short (<10m) [11] and the transmission ratio of ZigBee is a little slow [12] and neither of them is suitable for voice call which needs a longer effective communication range and faster transmission ratio. Hence, we'd better adopt other wireless communication technology. However, Wi-Fi is the choice.

Essentially, Wi-Fi is wireless LAN [13]. With Wi-Fi, it is possible to create high-speed wireless local area networks, and provides the possibility that computers which are not far away from each other could be connected together through an Access Point (AP). In practice, Wi-Fi can be used to provide high-speed connections (11 Mbps or greater) to laptop computers, desktop computers, personal digital assistants(PDAs) and any other devices located within a radius of several dozen meters indoors (in general 20m-50m away) or within several hundred meters outdoors [14]. With the promotion of smart phones, there are more and more mobile phones with Wi-Fi embedded. Most of applications need Access Point (AP) to access the Internet or conduct file sharing. The usage of AP limited these applications can only be available only in some specified areas [9], such as luxury hotels, luxury residential, air port or other special areas.

Based on these issues, it is naturally to conceive the idea of connecting two mobile phones directly through Wi-Fi, then based on this connection we can provide some services such as voice calls and so on. The birth of MANET (Mobile Ad-hoc Network) makes the concept possible.

Mobile Ad-hoc Network (MANET), sometimes called a mobile mesh network, is a self-configuring network of mobile devices connected by wireless links [1]. It has the following three key characters [2]:

- Each two hosts in network are connected by wireless links.
- Network could be established without a pre-existing infrastructure.
- Routes between nodes may potentially contain multiple hops.

And it has the advantages of easy deployment, high speed of deployment as well as decreased dependence on infrastructure [2].

Hence, in MANET each two nodes can be connected together without any other infrastructure. For example, Wireless Sensor Network (WSN) which is based on the technology of MANET has been widely used in science experiment [15]. Different from WSN, it is a problem to be considered that how to open the callee's Wi-Fi function if talk about making voice call through Wi-Fi. In order to solve this problem, we proposed an innovative approach. First, we'll send a kind of special SMS which acts as a signal to open the other side's Wi-Fi function, and then with the APIs provided by the mobile phone's OS, the two mobile phones could be connected in Ad-hoc mode. Based on this connection, we successfully to realize transporting voice data through directly Wi-Fi connection.

The rest of the paper is organized as follows. Section 2 described related works and overview. Second 3 described the current implementation of our application. Section 4 analyzed the max count of hops in order to keep the connection delay below 4 seconds. Section 4 showed the simulation results of the model created in second 3. Section 5 concludes the paper with discussions of the future work.

2. RELATED WORKS AND OVERVIEW

There are several wireless communication technologies such as Bluetooth and ZigBee for short-range and also long-range wireless communications technologies for voice call, such as Voice over Internet Protocol (Voice over IP, VoIP) [16].

2.1 Bluetooth overview

Bluetooth is an open wireless technology standard for exchanging data over short distances (using short wavelength radio transmissions) among fixed and mobile devices, it could create personal area networks (PANs) with high levels of security. It has the merit of low power consumption [17]. So it's widely used in mobile phones for short-range wireless communication, for example, we can send a file or build connection to notebook via Bluetooth, but most applications have the same character, the two or more nodes must be very close to each other because of the limitation of transmission distance(up to 10m) [18]. It is unnecessary to make voice call within such short distance.

2.2 ZigBee overview

ZigBee, a short-distance wireless network communication technology, which is low complexity, low power loss, low data ratio and low cost, mainly suits the situation of automatic control and remote control domain [10]. Because of its low data rate, it is unable to support large voice data transmission in real-time.

2.3 Voice over IP overview

Voice over Internet Protocol (Voice over IP, VoIP) [16] is a general term for a family of methodologies, communication protocols, and transmission technologies for delivery of voice communications and multimedia sessions over IP networks, such as the Internet. Skype is a famous communication software using VOIP. This is similar with our application considering they both are based on Wi-Fi; however, there is a key difference between them: in our approach AP is not needed for building the connection between two mobile phones.

3. ONE-HOP CONNECTION DESIGN AND REALIZATION

Voice call based on Ad-hoc network is a little different from most of other applications, it has the following characters:

- Fast connection. It's bound to affect its availability if the connection time is too long.
- Real-time transmission of large amounts of data.
- Less energy consumption, this is especially important for mobile phones.

Therefore, in order to ensure less connection delay and faster transmission speed, the count of network hops can't be too much. And also for the mobile applications, the available intermediate node is very limited, since the Wi-Fi function is usually closed at most time for saving power. Taking these factors into account, our current work aims to achieve a direct connection between two phones to make a short distance (For example, in the same building between the different floors) voice call. In addition, we must solve how to automatic connect the two sides even when the Wi-Fi are both closed. To solve this problem, we designed a method based on SMS to complete the initial connection.

3.1 Design

Our system framework is as follows (See Figure1):

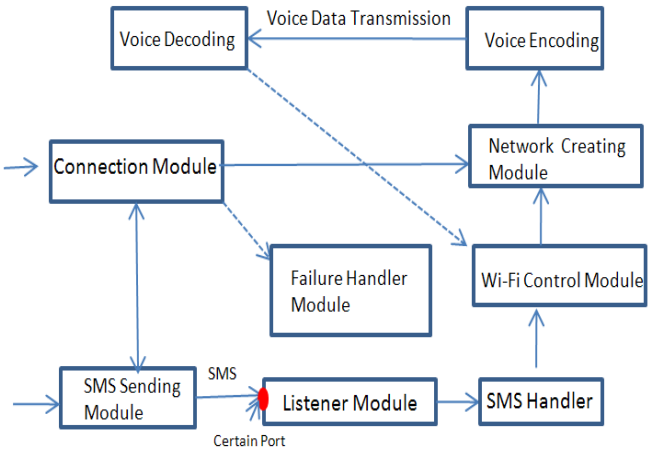


Figure 1. System framework

The SMS sending module is used to send a special SMS to inform the other side to open its Wi-Fi if it was closed before. The listener module will always run silently as a daemon to listen to a certain port. While a SMS arrives, the listener module will inform the SMS handler module to handler this event, it will open Wi-Fi via the Wi-Fi control module. Then an Ad-hoc network with a certain Service Set Identifier (SSID [3] is the name of a wireless local area network (WLAN). All wireless devices on a WLAN must employ the same SSID in order to communicate with each other) will be created. The connection module is used to connect two mobile phones together via the Ad-hoc network created by network creating module. The voice encoding and decoding module is used to encode and decode the voice.

3.2 Realization

Our design flow chart is as follows (Figure 2):

Whenever Phone A wishes to communicates with PhoneB, firstly it would try to connect to the wireless network whose SSID is PhoneB's number directly. If it fails, there are two possibilities: one possibility is that two phones are too far away from each other; and the second possibility is that Phone B may not open its Wi-Fi function. In this paper we only consider the later situation, since we can handle the former's failures by turning to the ordinary GSM network for voice calls. Then, Phone A will automatically send a specific SMS, equivalent to a signal, When Phone B received this SMS it would automatically open the Wi-Fi module in Ad-hoc mode whose SSID is Phone B's number. At the same time, Phone A would try to connect Phone B repeatedly in a certain period of time. If this process is successful, the voice call could be established; otherwise it could switch to GSM network.

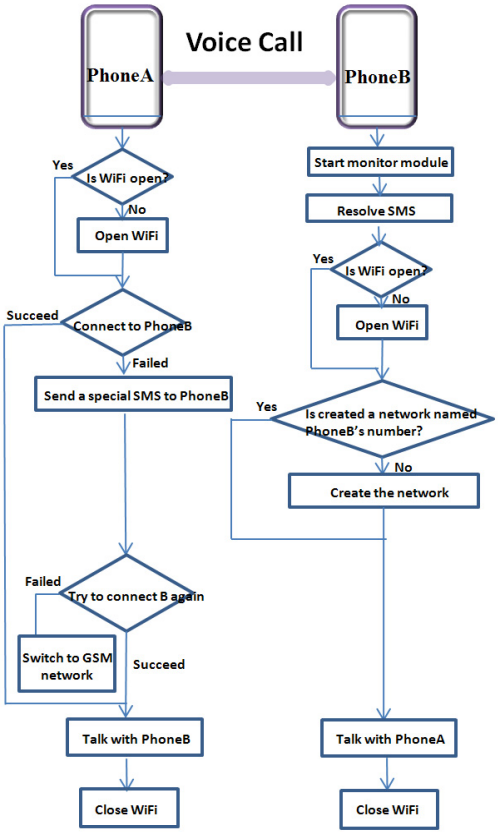


Figure 2. System flow chart

Here is the process of connection's pseudo-codes:

PhoneA's connection processing:
directly connected to PhoneB;

```
if( failed to connect to PhoneB)
    send a special SMS to PhoneB;
    start a timer;
    if (not overtime)
       while true do
          if ( failed to connect to PhoneB)
             try connecte to PhoneB;
        else
           goto voice call handler;
           break;
         endif
      done
    endif
  endif
```

PhoneB's response processing:
start the listener;
receive and resolve SMS;

```
if (Wi-Fi is closed)
    open Wi-Fi;
    create Ad-hoc network;
endif
```

start a timer;

```
if ( not overtime)
      while true do
         wait for connecting;
         if (connected successes)
            goto voice call handler;
            break
          endif
       done
endif
```

4. MULTI-HOP CONNECTION ANALYSIS

As mentioned before, voice call based on Ad-hoc networks is different from other applications, such as WSN [15]. It requires a shorter connection time delay which will increase with the network hops. So we will analyze the maximum number of hops at the premise of allowed connection time delay.

There are many protocols for MANET, These protocols generally fall into two categories: proactive or reactive [4]. Proactive routing attempts to maintain optimal routes to all destinations at all times, regardless of whether the connections are needed. In contrast, reactive or on-demand routing protocols determine routes to specific destinations only when there is data need to be delivered to destinations. If a route is unknown, the source node initiates a route lookup processing. According to our application requirement, we only need to create the connection when we want to make a voice call with other. It is easy to know that reactive protocol is preferable for route discovery considering its characters. Dynamic Source Routing protocol (DSR) [5] is one of these protocols.

Dynamic Source Routing protocol (DSR) [Johnson 1994, Johnson 1996a, Broch 1999a] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes [5], whenever a source node needs a route to a destination node, the protocol initiates a route discovery procedure. Route discovery procedure typically involves a network-wide flooding of a Route Request (RREQ) and waiting for a route reply [6]. The procedure is as follows (See Figure3):

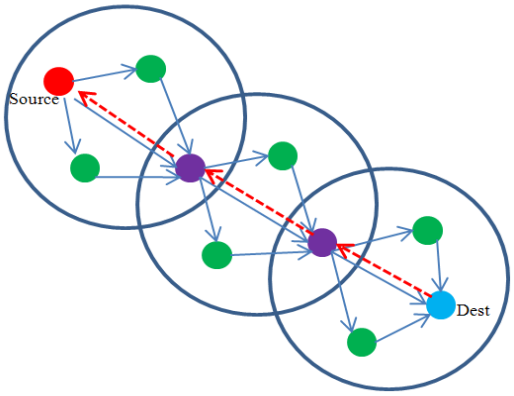


Figure 3. DSR routing procedure

From the above figure we know that while the source node wishes to connect to the destination node, it will broadcast RREQ, and each other nodes who receive this RREQ will broadcast it too till the destination node receives this RREQ or this RREQ is expired. Then the destination node will send the response request to the source node via the shortest path.

Before creating our mathematic model, in order to simplify our model, we make the following assumptions:

- Each node has the same packet delivery ratio.
- Cases of packet loss or errors during transmission will not occur.
- The transmission time of packet on wireless and processing time is uncared.

Consider a directed graph $G(N, E)$ (such as Figure 2), where N is the set of all nodes and E is the set of all directed links (i, j), where $i, j \in N$. Let S_i be the set of nodes that can be reached by node i within a certain power level in its dynamic range, link (i, j) exists if $j \in S_i$ [7]. Then, we assume that each packet (RREQ)

size is MBytes, each node's packet delivery ratio is Speed Mbits/s, so each packet's transmission delay is $t_{perPacket} = M * 8 / Speed$. We also assume that the max count of nodes that each node can reach is $\max Nodes$, so the path routing time is:

$$Delay = \sum_{i:j \in S_i}^{\max Nodes} t_{perPacket} * hopCount + t_{perPacket} * hopCount \quad \forall i \in N - Dest \tag{1}$$

where $hopCount$ denotes the hop count of network. And now we can get the total connection time as follows:

$$totalTime = Delay + t_{SMS} \tag{2}$$

where t_{SMS} is the SMS transmission delay.

5. SIMULATION RESULTS

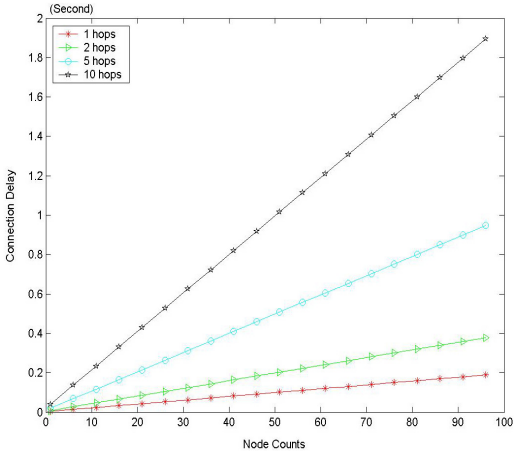
5.1 Simulation environment

The simulation codes were implemented with the Matrix Laboratory (MATLAB). In the simulation, We assume that $\forall \max Count \in S$,S = {1,2,5,10,20,30,40,50} , then hopCount means the count of network hops, we assign $hopCount \in (1,100)$ Besides these, we assign the symbol Mbytes = 512Bytes, SpeedMbit = 2Mbits/s [8].

5.2 Simulation goals

We have two goals in this simulation, first we want to verify the differences of connection time delay between one-hop connection and multi-hop connection (such as 2, 5, or 10 hops), second we want to know the max count of hops in different size of network if we want to keep the connection time delay less than 4 seconds.

5.3 Simulation results



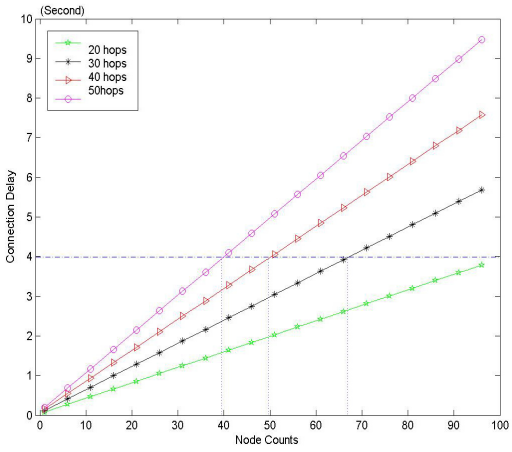


Figure 4. 1Hops~10Hops connection delay Figure 5. 20Hops~50Hops connection delay

From figure 4 we can see that the connection time delay of one-hop is slightly less than 2-hops but significantly less than 10-hops. From figure 5 we can see that in a 100 nodes network if we want to keep the connection time delay less than 4 seconds, the max count of network hops should be less than 20.

6. CONCLUSIONS AND FUTURE WORKS

In our paper, we implemented a short range voice call based on Ad-hoc network, and analyzed multi-hop network and get the related conclusion, for example, when the number of nodes is 100 in each area, in order to ensure the connection time no more than 4 seconds, the connection hop can's be greater than 20 hops.

But in Ah-hoc network, security is a very important issue, how to ensure the security of communications is a important work for us in future. In addition, the power consumption problem is also a key aspect we should consider.

7. ACKNOWLEDGEMENT

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8. REFERENCES

[1] Tomas Krag and Sebastian Büettrich. "Wireless Mesh Networking". O'Reilly Wireless Dev Center. Retrieved January 20 2009.

[2] Prof. Krishna Moorthy Sivalingam, Ph.D. Professor, Dept. of CSE, IIT Madras “Mobile Ad HocNetworks” http://www.cse.iitm.ac.in/~skrishnam/

[3] Bradley Mitchell “ SSID-Service Set Identifier “ http://compnetworking.about.com/cs/wireless/g/bldef_ssid/htm

[4] N. Schult, M. Mirhakkak D. LaRocca “Routing in Mobile Ad Hoc Networks” IEEE 1999

[5] David B. Johnson David A. Maltz Josh Broch “DSR: The Dynamic Source Routing Protocol for Multi-Hop Wireless Ad Hoc Networks” http://www.monarch.cs.cmu.edu/

[6] Mahesh K. Marina Samir R. Das “On-demand Multipath Distance Vector Routing in Ad Hoc Networks” Dept. of ECECS University of Cincinnati Cincinnati, OH 45221

[7] J-H. Chang and L. Tassiulas “Routing for Maximum System Lifetime in Wireless Ad-hoc Networks” Electrical and Computer Engineering Dept. & Institute for Systems Research University of Maryland College Park, MD 20742

[8] Amir Darehshoorzadeh, Nastooh Taheri Javan, Mehdi Dehghan, Mohammad khalili “LBAODV: A New Load Balancing Multipath Routing Algorithm for Mobile Ad hoc Networks” IEEE 2008 2nd Malaysia Conference on Photonics, 26-27 August 2008

[9] JiWire Mobile Audience Insights Report Q2 2010

[10] Li Wenfeng, Cao Guojun, HanFei “Short-distance Wireless Voice Communication Technology Based on ZigBee” IEEE Press, 20-22 Sept. 2009, doi: 10.1109/ICMSS.2009.5303753

[11] Newton, Harold.” *Newton’s telecom dictionary”*. New York: Flatiron Publishing.

[12] Liting Cao, Wei Jiang, Zhaoli Zhang “Networked Wireless Meter Reading System Based on ZigBee Technology” IEEE Press, 2-4 July 2008 , doi: 10.1109/CCDC.2008.4597971

[13] Datar, R.V. “Wi-Fi and WiMAX - break through in wireless access technologies” IEEE Press, 11-12 Jan. 2008, pp. 141-145, Print ISBN: 978-0-86341-887-7

[14] Kioskea, “Introduction to Wi-Fi (802.11 or Wi-Fi) “http://en.kioskea.net/contents/wifi/wifiintro.php3

[15] Rosa, N.S. ; Cunha, P.R.F. “Behavioural Specification of Wireless Sensor Network Applications” IEEE Press, 2-6 July 2007, PP. 66 – 72, doi: 10.1109/GIIS.2007.4404169

[16] "Voice over Internet Protocol. Definition and Overview". International Engineering Consortium. 2007. Retrieved 2009-04-27

[17] Rajeev Shorey, Brent A. Miller “The Bluetooth Technology: Merits and Limitations” IEEE Press, 2000 , pp. 80 - 84 , doi: 10.1109/ICPWC.2000.905777

[18] Anthony C Davies “An overview of Bluetooth Wireless TechnologyTMan d some competing LAN Standards” IEEE Press, 2002, pp. 206 – 211, doi: 10.1109/OCCSC.2002.1029081