Cost Free Voice Communication between two portable devices over Local Area Network using Bluetooth Technology

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Abstract: Bluetooth technology is used to transfer data over short distances between mobile devices. Once the mobile is enabled with Bluetooth technology, we can transfer data to another portable device located within certain range of distance at free of cost. This paper aims at developing an application used to transfer voice data between two portable devices which are out of Bluetooth range. This is possible when the two portable devices are connected to PC's which are in turn connected over LAN.

Keywords : Local Area Network(LAN) , Personal Computer(PC), Personal Digital Assistant(PDA) , Internet Protocol(IP), Transmission Control Protocol(TCP), Java 2 Micro Edition(J2ME), Network Interface Card(NIC), Java Virtual Machine(JVM)

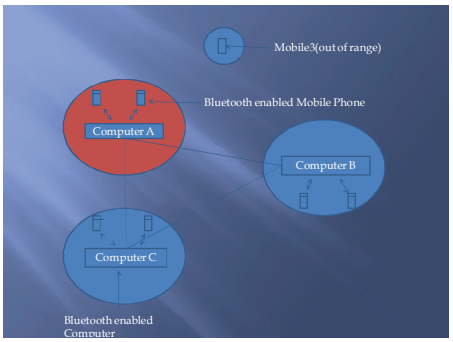
I. Introduction

Wireless communication plays an important role in present day life. We can have call facility , SMS facility etc. For this we have to pay certain amount of service charge to the service provider. This paper can be used to implement wireless communication services between two mobile phones without any service charges. It uses Bluetooth technology which is low cost, low power, short range radio technology intended to replace cable connections between cell phones and other portable devices. The communication services can be provided between two mobile phones separated beyond 10 meters range , provided the sender mobile and receiver mobile are connected to two different Bluetooth enabled PC's which are in turn connected using a LAN.

First, the signals are transmitted from source mobile phone to the connected PC which is within the range of 10 meters using Bluetooth technology and then the signals are transferred to the nearest host in the Bluetooth range of the destination mobile phone. Then this data is communicated to the destination phone.

II. Design

A. Hardware Architecture: Following figure shows the hardware architecture.



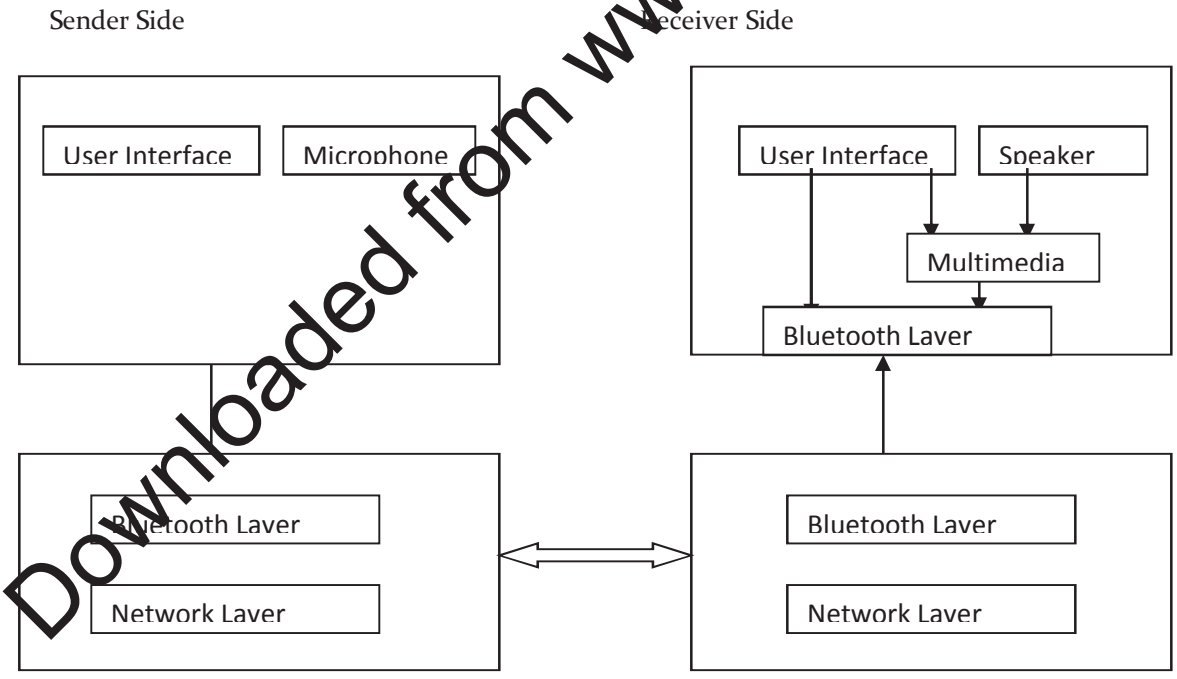
It shows computers connected via Local Area Network (LAN). Each computer is Bluetooth enabled and some Bluetooth enabled mobile phones are connected to them. The sender and receiver need not be within the Bluetooth range and they may be in the vicinity of different computers. The sender mobile sends the voice data to the computer present within it's Bluetooth range and then be transmitted to receiver computer (nearest computer in the Bluetooth range of destination mobile phone) via Local Area Network. This data is later transmitted to the receiver mobile.

B. Software Architecture

The sender/receiver mobile consists of four functional units. They are

1) User Interface: This is an interface between application and user. User can view the contacts, add new contact, set up a call by dialing the number. Appropriate messages such as "calling", "call terminated" etc are displayed to the user. The user at the receiver end enables the user to accept or reject the call.
2) Multi media: This unit is responsible for buffering audio data sent/received.
3) Hardware: It is the microphone for the sender to read the audio signals from the user and convert it to the digital data and speaker for the receiver to read audio signals received and playing it.
4) Bluetooth Communication Layer: At the sender side, this is responsible for transmitting audio packets and maintaining the connection with the sender side computer. At the receiver end, the unit is responsible for maintaining the connection with the receiver side computer and receiving the audio packets

The following figure depicts the system design.



The sender/Receiver side computer consist of two functional units each

1) Bluetooth Communication layer: This is for the communication between sender/receiver mobile phone and sender/receiver side computer. i.e., at the sender side, it waits for any incoming

connection request and receives the packets from sender mobile and forwards it. Similarly, at the receiver side the received data packets are forwarded to the receiver mobile.

2) Network Communication Layer: At the sender side , it waits for acknowledgement from the receiver and exchanges data packets. At the receiver end, the receiver side computer receives data packets from the sender side computer.

C. Classes Used:

The application consists of the following classes:

1) Buffer Class: The data structure called Buffer is used at the sender's and receiver's mobile phone. This indicates the length of the digital voice packets and also tells whether voice packets are available or not. The Buffer class is used at both sender's and receiver's end and is shared by multimedia and Bluetooth classes.
2) Control Flag Class: There is a data structure called Control Flag and is responsible for providing the control signals such as No Response, Terminate, Accept, Reject etc. to all the modules in the mobile side. Control Flag class is shared by all the modules at the mobile's end.
3) Multimedia handler class: This class is used at the sender's end to record or buffer the data which is then sent to receiver side.
4) Mobile Bluetooth class: At the sender mobile, this class is responsible for sending audio data to the personal computer in the Bluetooth range.
5) User Interface Frontend Class: This class provides the user a simple interface to use the application. The typical methods are ShowContacts(), addcontact(), call(), receive().
6) Bluetooth Listener class: This class present in the sender computer will listen to the incoming connection request from the senderside mobile and creates a data transfer object.
7) Network Listener Class: This class present at the receiverside computer will listen the requests from other computers and when there is an incoming request, it will create a data transfer object to serve the request.
8) Data Transfer Class : This class is used by Bluetooth listener and network listener classes

III.Technologies Used

1) J2ME: Java 2 Micro Edition provides a robust and flexible environment for applications running on mobile and embedded devices. This technology was originally created in order to deal with the constraints associated with building applications for small devices. It makes possible to create Java applications running on small devices with limited memory, display and power capacity.
2) Bluetooth: Bluetooth is a wireless technology standard for exchanging data over short distances. Invented by telecom vendor Ericsson in 1994, it was originally conceived as a wireless alternative to RS-232 data cables . It can connect several devices overcoming problems of synchronization.

   Bluetooth technology is a communication protocol that uses radio frequencies to establish common talking points between compatible devices. All Bluetooth communications take place from 2.4 to 2.485 GHz band, which is used only for electronic devices and appliances.

   The Bluetooth connection jumps from frequency to frequency (known as spread spectrum frequency hopping) thousands of times per second at random. This eliminates interference and increases security. Secured communication takes place because only the two linked devices know the pattern to unscramble the signal. The range of Bluetooth network is purposefully designed to be limited so that the devices donot use too much power. Most Bluetooth devices will stay in contact to a range of 10 meters. However we can find high power Bluetooth devices that work to a range of 100 feet.

IV Implementation

1. User Interface Module: This module is implemented at the sender's and receiver's mobile. It provides the user a way to interact with the system. The user can view the contact list and he can select the user with whom he wants to talk. The user can accept or reject calls. The user can also add new contacts into his existing contact list.

   Algorithm for User Interface at sender's end:

   Step1: Upon opening the application, the user is provided with the options-show contact list and adds contact.
   Step2: Read User's selection
   Step3: If option= 'add contact' then Read and add the new contact to the existing list.
   Step4: If option='show contact list' then Display the contact list.
   Step5: Read the user's input
   Step6: If option = 'call'

```
Begin
    Initiate the call
    Wait for time period 't', i.e., for receiver's response
    If no response within time period 't'
        Display "no response" and stop the application.
    If receiver's response='accept'
    Begin
        Display speak
        Read for user's input
        If input = call transfer
            Change the role of the sender and receiver.
        If input = terminate
            Stop the application.
    End
    If receiver's response= reject then stop the application.
End.
```

2. Multimedia Module: Multimedia module at the sender side is responsible for recording audio data for't' milliseconds. The recorded voice data is then stored in a buffer which is then forwarded to receiver mobile. At the receiver side, it is responsible for playing the audio data received from the sender side for 't' milliseconds.
3. Bluetooth Layer Module: Bluetooth is the transmission medium for communication between sender side mobile to nearest computer and between the receiver side computer and receiver side mobile. This module consists of four different stages:

   3.1. Sender side Mobile: The sender side mobile receives the receiver mobile's address with which call has to be set up. First, it checks whether a Bluetooth enabled computer is present in the current vicinity. If there is no such computer, it intimates the user interface module and exits. If computer is available, this module establishes the connection with the computer. Once the connection is established, the sender Bluetooth address is sent and it waits for the control packet from the computer and if the packet is "Not Found" it stops. If the packet is "Reject" it stops else if the packet is "Accept" , the multimedia module will start buffering the data and then write method will be called. It sends the buffered voice packets and control packets if any, to the computer. If the packet is "Transfer" then the read method will be invoked.

   3.2. Sender side Computer: In the sender side computer, there will be a Bluetooth listener object which establishes the service and waits for the incoming connections. When there is an

incoming connection, it creates a data transfer object to handle the connection , and goes back to listening state. The data transfer object receives the destination Bluetooth address and forward it to the network layer and then starts transferring the data from source mobile to the network layer.

3.3. Receiver side Computer: First, it receives the destination mobile's Bluetooth address . It checks whether the destination device is present in the vicinity. If not present , it intimates the network layer and exits. Otherwise establishes the connection and sends the source mobile's Bluetooth address to the destination mobile and intimates it to the network layer. Once the connection is established, it transfers data from network layer to mobile phone.

3.4. Receiver side Mobile Phone: Once the application is invoked at the receiver side mobile, it starts Bluetooth module , which will aquire the connection and receive the source address which is forwarded to the user interface module. Then it waits for the "Accept" signal and calls the read method which receives the packet from the nearest computer. And supplies it to the multimedia module for playing. If a "Transfer" packet is received , write method is called.

4. Network Module: This is responsible for sending the digital voice packets from computer at the sender side and to the computer at the receiver side. It also sends the control packets.

4.1. Network Module at Sender side: It first obtains the Bluetooth address of the destination mobile from the Bluetooth module. Then it will multicast the Bluetooth address to the computers which have the application installed. Then the module will create a process that will wait for time period't' . If no response is obtained, intimation is sent to the Bluetooth module that no response is received. Otherwise, with the information sent from the receiver side computer, the process created already at sender side computer establishes a TCP connection which acts as 'System-Mobile Thread'. It will listen for "Terminate" packet from the sender as well as the receiver. If it receives the "Terminate" packet then it will stop the application. When the connection is established, one more thread called Mobile-System thread' is created. It will listen to the packets from the Bluetooth module. It will send the packets to the receiver side computer until it gets a control packet.

4.2. Network Module at Receiver side: At the receiver side computer, this module waits for Bluetooth address sent by the sender. It forwards this address to the Bluetooth module and waits for response from it. If no response is obtained within time 't' , 'no response' intimation is sent to the sender side computer. Otherwise, it establishes a connection with the sender side computer which acts as System-Mobile thread'. This thread listens to the incoming digital voice packets from sender's side and forwards it to the Bluetooth module until a "Terminate" packet arrives. When the connection is established, this module creates another thread called 'Mobile-System thread'. This thread will be listening for packets from the receiver's mobile and will continue to do so until a "Terminate" packet arrives. Upon arrival of a "Terminate" packet the application is stopped.

V Conclusion

The voice communication is made possible by combining LAN and Bluetooth technologies. The development of this application is mainly concentrated on using the existing infrastructure available in the campus or organization. Thus communication becomes cheaper. A half-duplex form of communication is implemented in which only one user can speak at a time and the other one listens. This application is developed for smart phone supporting Java technology.

VI Further Enhancements Done

The paper can be extended to support for computers which have dynamic IP addresses. This is accomplished by having a centralized server. All other computers will register with the centralized server by

giving it's IP address. This extension is implemented by my students R. Ranjith Kumar, K. Moses David, Ch. Anusha ,K. Shiva Kumar and Ch. Abhiramu as partial fulfillment of the requirement for the award of B. Tech degree in Information Technology Department at Christu Jyothi Institute of Technology and Science during the year 2012-13 under my guidance.

They have written a client program and server program using Java. The client reads the voice signal from the source mobile (Before this the mobile must get registered at that client) and sends it to the server process installed in the centralized server. Then the server process broadcasts the voice packets to all clients connected. The client under whose vicinity the destination mobile is present, accepts the voice packets and transmits to the destination mobile My students have practically implemented this application by executing client program and server program concurrently and then transmitting voice from client to server and then back to client (which may be connected to the destination mobile). In fact , it is a simulation. In a real situation , the exe files of client program has to be installed on number of clients connected in LAN and server exe file on centralized server.

VII Future Enhancements to be done

The application can be enhanced with additional features such as :

- Full Duplex mode of communication can be supported. This can be achieved by having two connections between communication parties.
- Connection can be maintained even if the user moves between the ranges. This can be achieved by initiating the nearby computer that there may be an out of range condition which has to be taken care of.

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