Project 1

Teams of 2
Due Date : 4/28/2014

Designing a wireless acoustic communication channel on an android phone with

1) Data rate – number of bits communicated per second – atleast 500 bps
2) Bit error rate – Ratio of the number of bits correctly received to the number of bits sent – less than 2%

Components:

1) Sender: An android app that
    - Takes a file or a short message as input and convert it to actual bits
    - Modulates the bits to a signal that can sent
    - Send the signal over an acoustic channel
2) Receiver: An android app
    - Receives the acoustic signal
    - Decodes the signal to bits
    - Display the message

Prerequisites – (Skip if you already have android programming platform setup in your machine)

Set up a machine for android programming

1) Make sure your system has Java jdk and jre installed.

There are two good IDE's for android programming – 1) Eclipse 2) Android Studio. You can use **either of the one** to write and debug your code.

1) Eclipse – The easiest way to install eclipse and set it up to write android code is to download and install – Android ADT bundle. The ADT bundle comes handily with an eclipse and also installs the android sdk and the adt plugins you need for eclipse.

   Just follow the steps in this link

   http://developer.android.com/sdk/installing/bundle.html

   ii) Even if you already have an eclipse, I will recommend you to use the above method as it is easier and takes less effort. Having more than one eclipse in your machine will not be an issue. However if you want to setup android in

your current eclipse setup, you need to install the android sdk and the adt plugins for eclipse separately.

Follow the steps in this link

https://developer.android.com/sdk/installing/index.html

2) The second option is to use android studio. Similar to the previous method, it comes with the sdk and an IDE of its own.
Follow the steps given under installing the android studio

http://developer.android.com/sdk/installing/studio.html

Android programming tutorials

For people new to android programming I suggest that you first try writjng a basic app to understand the android programming structure mainly the concept of activity.

https://developer.android.com/training/basics/firstapp/creating-project.html

This link is a sample tutorial that takes you step by step in writing your first app and installing it on you phone using eclipse IDE. You can also debug your app while it is running on the phone.

http://www.i-programmer.info/programming/android/5887-android-adventures-getting-started-with-android-studio.html?start=3

This is an other sample tutorial, which explains the android programming structure and also gives you the steps to write an app using android studio.

The structure of eclipse and android studio will be slightly different.
However most of the tutorials are applicable for both.

Project Implementation Steps:

1) Sender app:

   Step 1: Add a textbox to your app to enter a message or filename as input. Have a Send button which will invoke the send function on click

   Step 2: Write a function Send(string message)

i) This function should first convert the string to a bit array of 0's and 1's. This forms the actual payload. Any payload is preceded with a header. The header in this case will have the Source, destination and length of the packet – number of bits in the packet. The total data to be sent is Header+payload.
Note: The header should always have a fixed length

ii) Then choose a frequency in which you are going to operate. The frequency available to you is 0-20Khz as the speaker and microphone in your phone will support only this range. However it is wise to check the frequency response of the speaker/microphone pair and choose an appropriate frequency. Usually frequency from 1- 12 KHz will be suitable. Generate a carrier wave (Sine wave) of this frequency.

iii): Write a function Modulate(bits, carrier wave, bitspersymbol) which modulates the data bits using a modulation scheme like ASK, PSK etc. The bitspersymbol defines the number of bits used to represent one data bit. This parameter and the modulation scheme will determine your data rate.

iv) Typically you can send this signal using the speaker. However to identify the start of the data at the receiver, every data packet is preceded by a preamble. A preamble is sequence of bits known by both the sender and the receiver. The receiver looks for the preamble and once it identifies the preamble, it decodes the data that proceeds it. A preamble is a signal that can be easily identified at the receiver. So, choose an appropriate pattern of some length as your preamble.

v) Now use the AudioTrack api to send the preamble+data using the speaker

2) Receiver app:

i) Write a recorder using the AudioRecord api. It should record samples from the microphone and store it in a buffer.
ii) Process the samples in the buffer to identify the preamble.
iii) Once you identify the start of the preamble, you can start decoding the data that proceeds it. Decoding the header gives the length of the data. Then decode the entire data.
iv) Convert the bits to a string and display it in a textbox.

Sophisticated Techniques:

The above steps detailed are the basic components for your communication channel. However you can do other sophisticated techniques to make your channel more efficient

At the Sender:
1)Use a preamble that has high detection accuracy but a shorter length
2) Use a good modulation scheme to increase your data rate
3) Use better coding techniques to reduce the bit error rate at the receiver as you increase your data rate.

At the receiver:
1) You can design some filtering techniques to filter the environment noise.
2) Do some channel estimation to improve the decoding process.

You can apply many smart techniques to make your communication channel efficient.

Report:

Now you can start playing with the app.

Task 1: Send a 1Kb file repeatedly for 10 times from one phone to another when they are placed next to each other. Find the average bit error rate achieved.

Task 2: Now increase the distance between the two phones by 10cms and find the average bit error rate each time. Plot a graph of the average BER with respect to the distance between the two phones.

Finally report the following in a document

1) Modulation scheme used
2) Number of bits per symbol used
3) Data rate achieved
4) Bit error rate
5) The maximum distance between the phones at which the BER is still less than 2 %

Also report any design decisions or sophisticated techniques you applie while implementing the communication channel.

Extra Credit:

For the team with maximum bit rate

For the team that achieves maximum distance of communication
(In both the cases the BER should be less than 2%)