HotMobile 2012 Poster: Audio-WiFi: Audio Channel Assisted WiFi Network for Smart Phones

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I. Introduction

Wi-Fi is becoming widely popular network interface for data communication in smart phones because of its high throughput, power efficiency and relatively large range. However, the Wi-Fi network still several inefficiencies in terms of high energy consumption, unfairness between co-located nodes, and bandwidth poor utilization. For example, Wi-Fi transmitter has to transmit the full packet even if the receiver could flags the packet as corrupted one at early stage of the transmission. Another example, Wi-Fi transmits control packets (RTS/CTS/ACK) low rate. Researchers have proposed to use other existing wireless network interface (Bluetooth , ZigBee etc.) as a parallel communication for enhancing the performance of Wi-Fi network by addressing above issues. Although the solution of using bluetooth and ZigBee in parallel with-WiFi improves the performance, it creates severe interference with Wi-Fi for communicating in the same frequency band (2.4GHz).

In our project, we like to enhance the performance of data communication over the Wi-Fi network by integrating the mic/speaker of the smart phones as a parallel communication channel. Our idea is to propose a novel framework of communication using mic/speaker in order to develop a more efficient Wi-Fi network communication. The non-interferential nature with Wi-Fi network is the biggest advantage of using audio communication channel for this purpose. For audio communication we like to exploit frequency band beyond normal human ear perception. At our knowledge, most of the smart phones are both capable of generating and discerning audio frequency beyond human ear perception.

II. Audio-WiFi Network

CSMA/CA protocol in Wi-Fi network fails to maintain a fair and efficient utilization of wireless channel. For instance, the wireless transmitter cannot detect packet loss, or collision in oder to abort its transmission before transmitting the full packet. As a result the channel remain useless during the corrupted packet transmission. In this scenario we can use the audio communication as a parallel channel to let a transmitter know about the packet loss and abort the packet transmission for better utilization of the channel. The audio channel could be used to coordinate between nodes in Wi-Fi network in order to eliminate the collision. As a consequence, eliminating collision will minimize the contention window and enhance the overall throughput of Wi-Fi network. Assuming the audio interface hardware (speaker/mic) consumes less energy then Wi-Fi receiver, then we can actually turn off the Wi-Fi rather than putting it to sleep during an inactive period. Later, we could turn on theWi-Fi by sending a control message using the audio channel to make active interaction between Wi-Fi node. In summary, we aim to explore how to utilize the audio communication to enhance the performance of Wi-Fi communication.

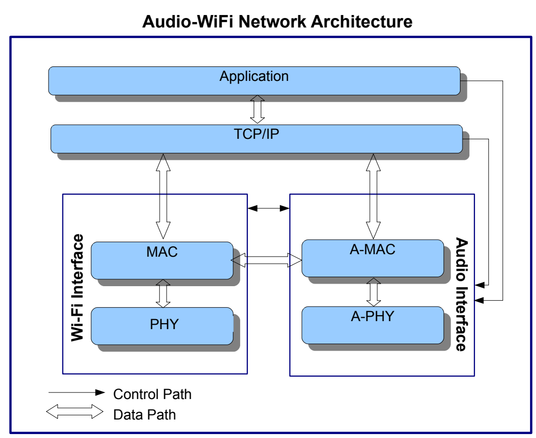

Figure 2: Proposed Audio-WiFi Framework Architecture. The single line arrow represents control path and the double lined arrow represents data path.

Figure 1 depicts the preliminary architecture of our proposed Audio- WiFi network including Wi-Fi interface and Audio interface. The Audio interface has two layers: 1)A-PHY layer: responsible for all signal processing, modulation/demodulation and transmit-

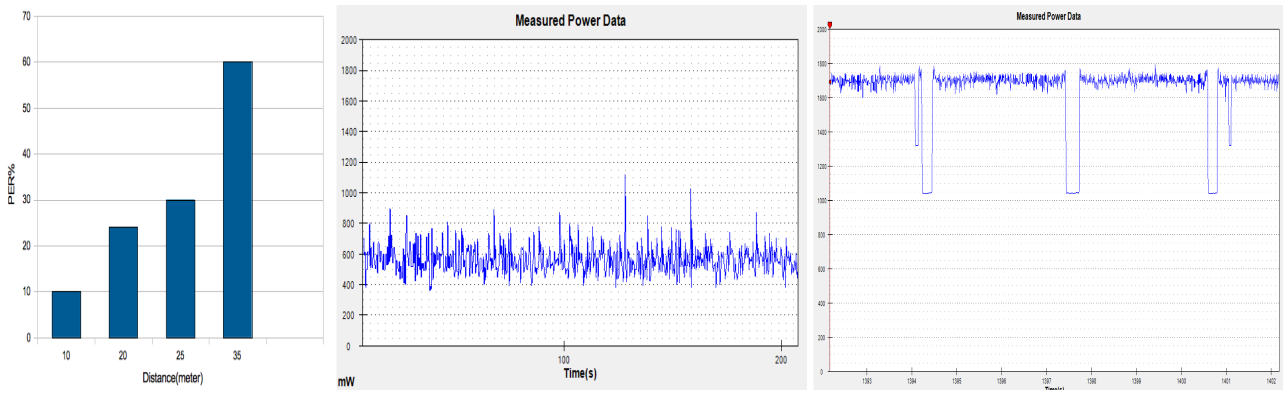

Figure 1: (a) Packet Error Rate (PER) over different distances. (b) Power monitoring when audio interface is receiving data.(c)Power monitoring when wifi interface is receiving data

ting/receiving signal using speaker/mic hardware. 2) A-MAC layer: responsible for sending/receiving data frames over acoustic media. The MAC and TCP/IP layers could took the benefit of using acoustic media to send control data frames using the A-MAC layer in Audio interface. In other way, A-MAC could receive control/ acknowledgment data frames over acoustic media and send it to TCP/IP and MAC layer. In order to control these data flows we need to maintain a control informations among the Application, TCP/IP, MAC layers with Audio interface. One of our research focus is to identify the proper control informations flow among them.

III. Challenges

Radio wave use electromagnetic properties and audio wave use air pressure for wave propagation. Therefore, audio wave is much slower then radio wave. In addition, audio channel suffer very low data rate compare to other wireless channel. Moreover, the effect of Doppler, reverberation and the background noise make it harder to increase the data rate over audio. In order to address this challenge, we can utilize the audio channel to send small control frame or signature tone as an additional assisted channel for WiFi instead of sending actual data. Utilizing audio channel as an assisted channel for WiFi emerges new challenge for Frame-level synchronization between WiFi and audio interface. As a possible solution we could send one control frame over the audio channel for a number of WiFi frames.

IV. On going Work

Wireless communication using acoustic signal is a common practice in underwater data communication. Researchers also have conducted several experiment of using acoustic communication in air medium . In order to analyze the audio communication range in air, we conduct a simple experiment to see Packet Error Rate(PER) over different distances. During our experiment, we keep same data transmission rate over multiple distances. Note that, high data rate is not important for our intended purposes. Considering these situations, we run our experiment in a 40 meters length long corridor. In our experiment, we use 7.5sps(Symbol per second) or 30bps as data transmission rate. In our audio transmission we use 25 bytes as a packet size, which is the maximum size of any wifi control frame. In the plot 1, we calculate the percentage of PER by sending 50 packets from each distance and then we count how many packets have been corrupted. However, the plot 1, does not make any concluding remarks on audio data communication range. In order to do that, further studies need to be done on the characteristics of PER over different indoor/outdoor ranges.

As an ongoing work, we use the monsoon hardware to measure the energy consumption of audio interface while receiving data over audio channel. We also measured the energy consumption of WiFi interface while receiving data over WiFi channel. From Figure 1, we see that audio interface consume on average 600mW of power. On the other hand, In Figure 1 we see that WiFi interface consumes 1700mW of power. Although, the audio interface faces the challenge of low data rate, but the audio interface consume about one third of the energy consume by the WiFi interface. As a future work for *Audio-WiFi* project, we like to do the followings, first, utilizing the audio channel to enhance the performance of Power Save(PS) mechanism of 802.11. Second, Using audio channel as an control channel for sending ACK frames while WiFi is sending data frames. Third, Utilizing audio channel for co-ordinating between nodes to reduce the collision.