Focusing on Energy Consumption in Data Transfer and its Minimization using Bluetooth and Wi-Fi

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Abstract

In today's world, there is an increasing demand of high data transfer rates in the IT industry which is highly achieved at the expense of a large amount of energy. The most common way to establish communication between the devices is to use Wi-Fi whether it is being used to browse internet or being used to transfer the data. The basic Wi-Fi offers high bandwidth which is much greater when compared to what Bluetooth provides. At the same time, while using mobile phones in specific, Wi-Fi uses a lot more power as compared to Bluetooth (active as well as inactive mode), which reduces the battery efficiency of the mobile phones. To overcome this issue, we propose to use Bluetooth and Wi-Fi alternatively by switching between these technologies based on the application requirements demand raised instead of performing the switching process based on the bandwidth used. The proposed scheme doesn't require any change to the mobile applications but still increases the battery efficiency of the mobile devices and reduces the power consumption of data transfer.

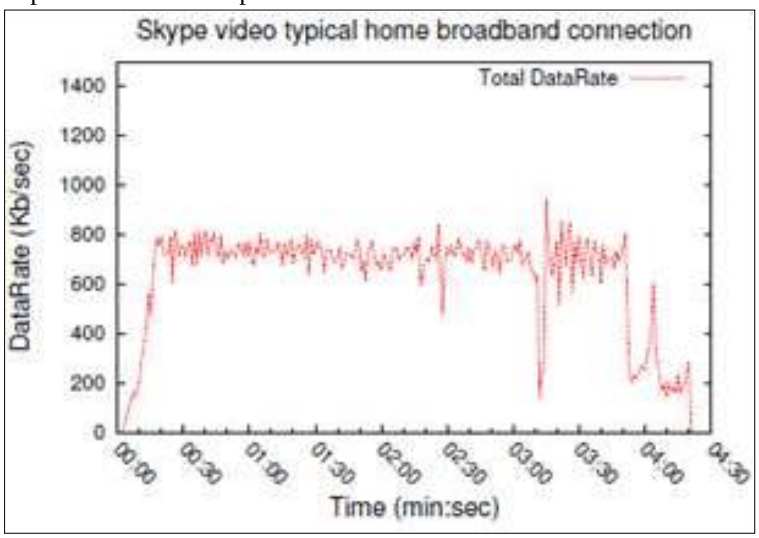
Keywords- Wi-Fi, Wi-Fi Tethering, Bluetooth, Power Consumption, Battery Efficiency

I. INTRODUCTION

The main objective of this research is to use Bluetooth and Wi-Fi alternately to transfer the data which will reduce the total power consumption and increase the battery life time of the device. The proposed model focuses on the ways to switch between Wi-Fi and Bluetooth based on the requirements of the application being used by the user which means when an application require high performance Wi-Fi will be used else Bluetooth.

We also show how application based switching is more efficient when compared to the present day techniques which include bandwidth switching. The output will be wireless system which will reduce the energy consumption up to 50% and effectively increase the battery life of the entire system.

Wi-Fi tethering will be used for data communication in our model. Tethering allows sharing the Internet connection of the phone or tablet with other devices such as laptops. If tethering is done over WLAN, the feature may be branded as a mobile hotspot, which allows the Smartphone to serve as a portable router.



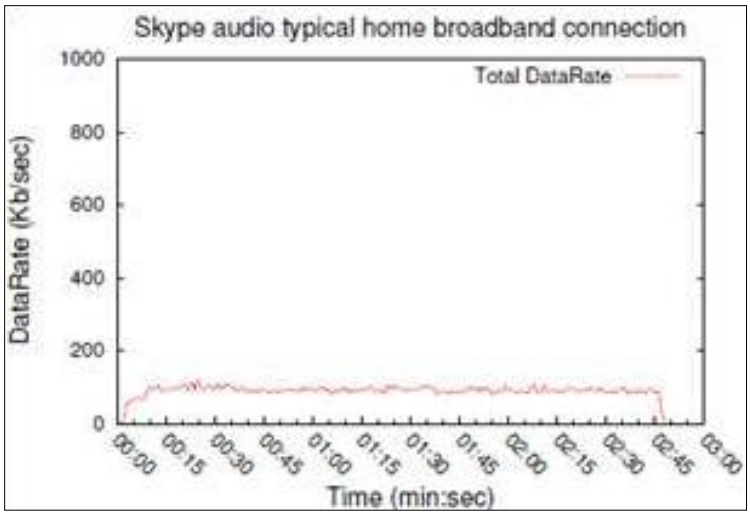
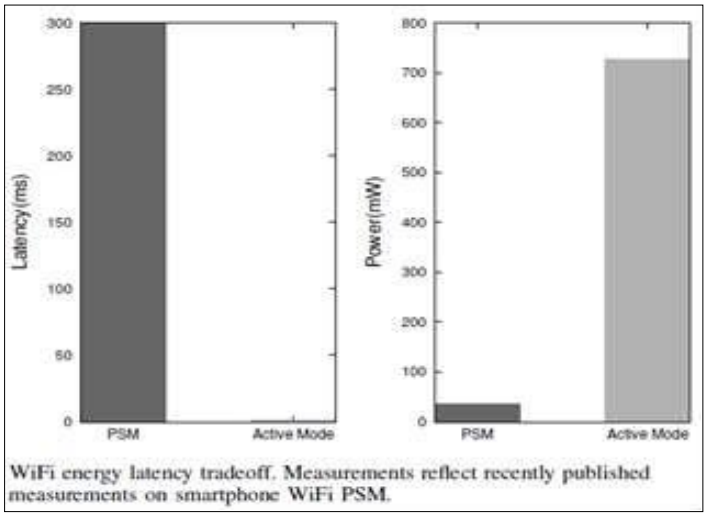


Fig. 1: Cases Where Bluetooth can be used [Pyles,2015]

Existing tethering schemes consume a lot of power because the Wi-Fi module is always in a high powerred state even if there is no traffic on the system and according to IEEE 802.11 standards an Access Point should never enter Power Saving Mode (PSM). So we designed a simple system where the mobile phone automatically switches between the Wi-Fi inter face and the Bluetooth Interface depending on the type of application being used by the user.

The proposed system does not require any changes to the mobile applications. The developed system is capable of reducing the power consumption significantly and increases the battery life of the device.



WiFi energy latency tradeoff. Measurements reflect recently published measurements on smartphone WiFi PSM.

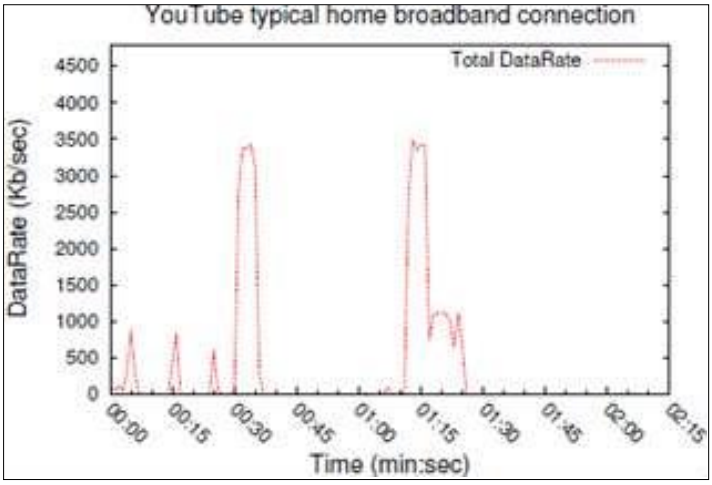


Fig. 2: Cases Where Wi-Fi can be used [Pyles,2015]

II. LITERATURE SURVEY

The concept of using Wi-Fi and Bluetooth alternatively to transfer the data has not been explored much because the data transfer rates in the old Bluetooth versions were significantly low as compared to the present day technology.[24][25]

Wi-Fi compatible devices can connect to internet using WLAN network and a wireless access point. Such access point has a range of 66 feet can provide good networking and hotspots within the range. [23] Wi-Fi use high frequency more than that of cell phones, televisions, walkie-talkie and other networking devices, using 802.11a standards which enable them to work at 5 gigahertz and can transmit data up to 54 megabits of data per second. The higher frequency signals allow them to carry more data at each second unlike than that of new technology of Bluetooth. But the main disadvantage of using the Wi-Fi design is its high power consumption rate, which measures to about 890 mW during active data transfers state, compared to only 120 mW for Bluetooth due to a limited range and simpler radio architecture. Moreover Bluetooth is optimized to be in an extremely low-power state operating at only a 2% power duty-cycle, typically consuming on the order of 1 mW while still remaining available for device discovery and connection setup. By comparison we know WiFi is based on CSMA and, although recent implementations support a Power Saving Mode (PSM), the underlying design means that typical power consumption even though reduced is still close to250 mW in this state. [22] This idea was presented by Trevor Pering in 2006 where a technique called Coolspots was used to reduce the power consumption of the device by using the Wi-Fi and Bluetooth alternatively. [6][14].

The switching was based on measuring the Bandwidth at regular intervals. In this research we use application based switching which will be energy efficient when compared to the continuous measuring of bandwidth.[15]

As mentioned in above scenario our research work we will be using latest Bluetooth model (version 5 due to max. range and efficiency) for switching between the Bluetooth Wi-Fi .[5][12][21]

Table 1: cited ref [5]

Bluetooth Version	*Data Transfer rate*	*Maximum Range*
Version 3.0	*25 Mbit/s*	
Version 4.0	*25 Mbit/s*	*200 feet(60 m)*
Version 5.0	*50 Mbit/s*	*800 feet(240 m)*

This will further improve the usability of the final system.

Bluetooth as a device explains the concept of limiting the power consumption, but on the same time if we need to transfer maximum data which can be passed over Wi-Fi, a high frequency wireless network technology.[7]

This will enable the device to switch between wireless radio waves automatically according to the need of the device and incoming file or outgoing file, streaming of data, audio and web browsing can save up to 50% with high efficiency. [15[22] The system will be implemented by using a switch algorithm using the user base [15] and information taken from other references. The algorithm will check the size of the file and will switch between Bluetooth and Wi-Fi accordingly. This can also be chosen by the user input. [7] [15]

Tethering is a concept which will also be used in our project. The system will also be modifying its current implementation to improve the overall project.

Tethering is connecting one device to another. If tethering is done over WLAN, the feature may be branded as a mobile hotspot, which allows the smartphone to serve as a portable router and allow them to share network [10]
We design a simple yet reliable sleep protocol to coordinate the sleep schedule of the tethering phone with its clients without requiring tight time synchronization. [9] [15][19].

Our technology is to switch between sleep and wake up mode to save energy which get wasted unnecessarily when there is no data transfer using [6][19]

The research includes a theoretical comparison which will prove how the proposed system can increase the efficiency of the mobile devices.

III. PROBLEM FORMULATION

Today there is an increasing demand of high data transfer rates. Wi-Fi is the most common way to establish communication between the devices to transfer data. The basic Wi-Fi offers high bandwidth which is much greater when compared to what Bluetooth provides. For the transfer of data either Wi-Fi or Bluetooth can be used but Wi-Fi has become more popular because of high data transfer speed. But unfortunately the power consumption of Wi-Fi is much more as compared to Bluetooth. This reduces the overall performance and efficiency of the battery. This problem becomes more prevalent in today's mobile devices where the size of the battery is limited. Moreover, continuous high consumption of battery also leads to overheating of the device. To overcome this issue, we propose to use Bluetooth and Wi-Fi alternatively by switching between these technologies based on the application requirements demand raised instead of performing the switching process based on the bandwidth used. Previously, this model has been implemented in two researches named as Coolspots [15] and Bluesaver [25]. Both these methods are based of calculating the status of the connected devices i.e. measuring the data rates of Bluetooth and Wi-Fi and then performing the switching operation.

Coolspots [15] technique will keep only one device in on mode at a time where as the Bluesaver[25] keeps both the devices on but in the Power Saving Mode. The first technique is less efficient as every time a switch has to be performed, the device will have to switch on a new mode of transfer (Wi-Fi or Bluetooth); this will increase the overall latency. But in the first case as both the modes of transfer are in on state the basic power consumption will be more.

In the developed system latest version of Bluetooth i.e. version 5 was added as an active device to transmit small size data over the network, as already mentioned previously that Bluetooth version 5.0 has an increased range in comparisons with previously available versions, this version of Bluetooth will enhance the range, and speed at which data will be sent to the client when requested by the server. Also power savings will be enhanced by using the latest technology of this Bluetooth device in our device.

To solve this issue we propose a system, where the switching will be application based. This means, if the data rate required by an application is more than the max data rate provided by the Bluetooth then the device will switch over to Wi-Fi.

IV. METHODOLOGY

The proposed system uses the benefits of Wi-Fi as well as Bluetooth to conserve the energy. As discussed before, better way to obtain high efficiency is to switch between Wi-Fi and Bluetooth, rather than using any one of them continuously. In our system this switching is based on the demands of the application.

The system diagram (Fig.3) explains the process of switching between Bluetooth and Wi-Fi based on the Data needs of the running Application the mobile phone. The Access Point discussed here is capable of transferring data using Wi-Fi as well as Bluetooth at a time.

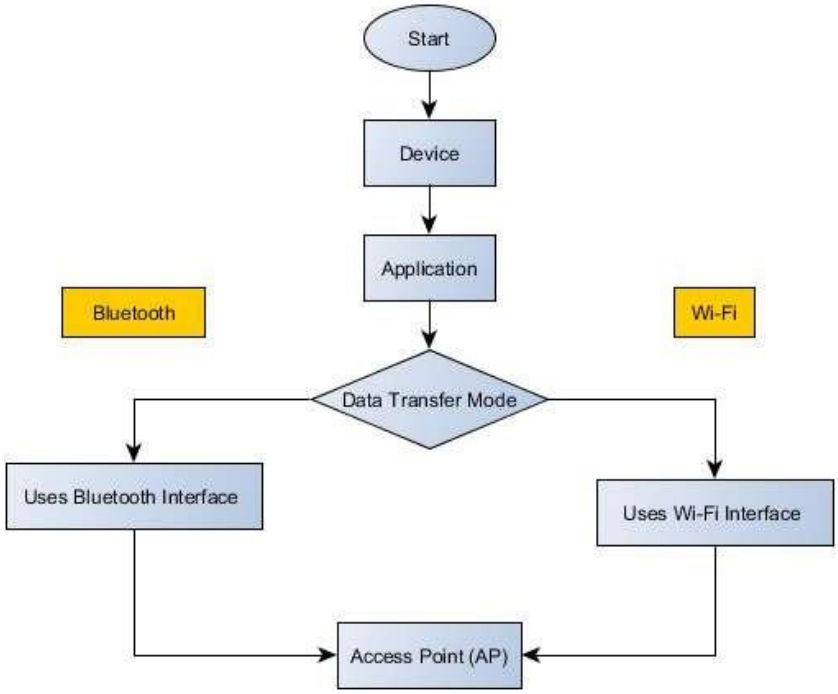


Fig. 3: System Design

V. SYSTEM ARCHITECTURE

The switching between Bluetooth and Wi-Fi is decided by the needs of the application. When a user opens an application on his phone which requires the use of internet; the operating system detects the type of application the user is opening. According to this information the operating system switches between Wi-Fi and Bluetooth. This information will be obtained from the Application running on the phone.

Example- when user opens YouTube or Snapchat, the operating system will automatically choose Wi-Fi and if we use WhatsApp or Skype then the operating system chooses Bluetooth.

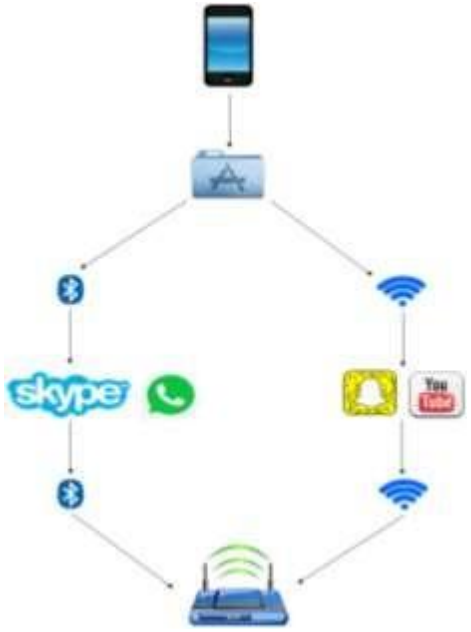


Fig. 4: System Architecture

VI. SIMULATIONS AND RESULTS

After the development of the system, the system efficiency was measured using Trepn Profiler android mobile application. The Fig. 5 shows the Power Usage consumption during the Use of YOUTUBE application where the data was transmitted over Bluetooth.

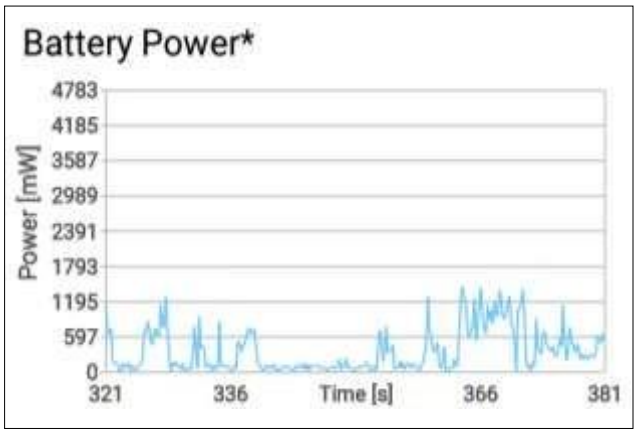


Fig. 5: Simulation 1

The Fig. 6 shows the Power Usage consumption during the Use of YouTube application where the data was transmitted over Wi-Fi.

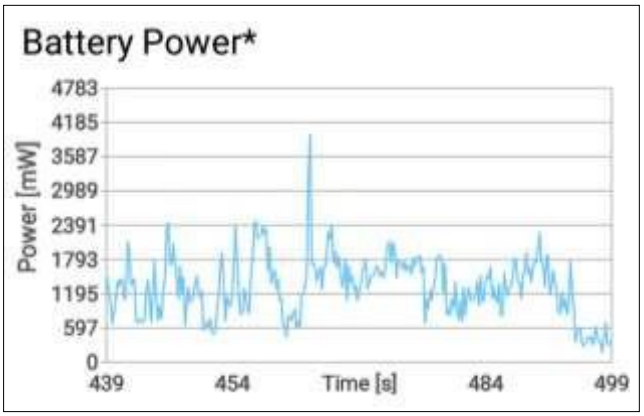


Fig. 6: Simulation 2

VII. DISCUSSIONS AND RESULTS

When the Fig.5 is compared with Fig.6, it can be observed that the energy consumed by Bluetooth is lower as compared to the energy consumed by Wi-Fi. The Fig.5 shows that the energy used in case of Bluetooth is low as well as continuous but in case of Wi-Fi (Fig.6) the energy used is high and has irregular peaks.

A. Calculations

Situation- The proposed system used Bluetooth for using YouTube but in case of normal condition Wi-Fi is being used. Using the results from Fig.5 and Fig.6-

= ((2391-1195)/2391)* 100

= 50%

Therefore the proposed system is capable of saving 50% of the battery consumption when compared to normal operations.

*Simulation Conditions- The tests were performed on Sony M2 Dual running Android 5.1.1. in Airplane Mode On and by closing all the background application possible.

VIII. COMPARING WITH PRESENT TECHNIQUES

For the purpose of comparison we choose two research papers- Coolspot [15] and Bluesaver [25] which uses different technique of switching. Both are based on the data bandwidth, but the first technique continuously keeps the Wi-Fi and Bluetooth in the open state; and other technique alternatively opens and closes the Wi-Fi and Bluetooth which is an unnecessarily waste of energy.

The proposed method uses the information provided by the application to perform the switching operation which eliminates the need to measure the bandwidth continuously. The existing models after getting the bandwidth information switch On Bluetooth or Wi-Fi accordingly, which further consumes a lot of battery and adds up to the latency.

Therefore the developed system saves the battery and ensures the performance at the same time.

IX. CONCLUSION

Smart phones today suffer from one basic problem of power consumption. Most of the power is consumed by the mobile data usage. To address this problem, we have presented a novel approach which combines the benefits of Wi-Fi as well as Bluetooth. This approach collaborates the low power consumption characteristics of Bluetooth with high speed characteristics of Wi-Fi. Finally, we have demonstrated that we can save up to 50% energy when compared to normal execution. This value it doubles when compared to existing systems.

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