RESEARCH ARTICLE OPEN ACCESS

Battery-Bandwidth Based Handover Framework for 3G/WLAN Using Android Handheld Devices

Apoorva Prakash M V*, Dr. M C Padma**
*PG Student, (Department of Computer Science & Engineering, PES College Of Engineering, Mandya)
**Professor & Head, (Department of Computer Science & Engineering, PES College Of Engineering, Mandya)

ABSTRACT
In a heterogeneous network environment, transparent horizontal and vertical handover is a much desired feature. Effective handover solution would allow mobile device users to stay steadily connected, seamlessly switching between different access networks. If it is consistently connected to networks which offers best Quality of Service (QoS) then that would dramatically improve user experience. Switching of network requires more device energy and also high bandwidth to guarantee the QoS. Automatic handover between 3G and WLAN networks is typically done when the current network link is going down. Current devices does not consider these two major metrics during handover. Hence, we propose a framework for creating our own custom handover solutions which could run on the clients' Android based mobile devices. To provide an example of using the framework, we implement and test our proposed framework in Android based hand held devices and showcase the improvement in QoS.
Keywords-: 3G, Android, battery, handover, remaining energy, seamless switching, WLAN

I. Introduction

Android is an operating system based on the Linux kernel, and designed primarily for touchscreen mobile devices such as smartphones and tablet computers. Android is the world's most widely used smartphone platform, overtaking Symbian in the fourth quarter of 2010. Android is popular with technology companies which require a ready-made, low-cost and customizable operating system for high-tech devices. Despite being primarily designed for phones and tablets, it also has been used in televisions, gaming consoles, digital cameras and other electronics. Android's open nature has encouraged a large community of developers and enthusiasts to use the open-source code as a foundation for community-driven projects, which add new features for advanced users or bring Android to devices which were officially released running other operating systems. Modern smartphone users expect to always stay connected. Therefore, seamless handover forms a crucial part of smooth network experience, especially in heterogeneous network environments. In the Context of telecommunications, the main purpose of doing a handover is to transfer the radio connection between radio channels, while maintaining an ongoing connection. A handover operation that can minimize or even eliminate the delay for establishing the new connection to the new access point (AP) is called a fast handover. If the handover operation minimizes the data loss during the establishment of the new connection, then it is called a smooth handover. A handover that is both fast and smooth is called a Seamless handover. Transparent horizontal handover (handover between networks of the same type) is supported in some form by nearly all smartphones. Exceptions include some of the modern Android phones that cannot perform handover between two Wi-Fi APs with the same ESSID [9] [10]. When multiple access networks are available, such as a public WiFi and 3G carrier, the mobile devices supporting both 3G networks and WLANs could benefit from this situation. For instance, connection to a WLAN with strong signal can be used when the device is near the public access point, because it is typically faster and cheaper than 3G. However, when the WLAN signal gets weak, 3G network becomes a strongly preferable option.

The default mechanism which is present with any android phone is that it would switch from 3G to WLAN in the presence of a known Wi-Fi network, or would switch between WLAN to 3G in the absence of any known Wi-Fi network. However when we are at home or office, there will be ample signal strength of either of the two, so always the WLAN would be active no matter whether Wi-Fi is running or not or else if it's slow or not. As manually choosing access networks over and over again is tedious, some automatic 3G/WLAN handover solution is needed. A lot of the research in this area is focused on LinkGoingDown(LGD) triggers, which are used to start handover before the current link goes down. The typical solution there, is to measure the received signal strength indicator (RSSI) or received signal level of current link, and start handover if the parameter is below some threshold. Similar strategy can be applied to choose the best current access network. For seamless vertical handover (handover between different types of networks), QUALCOMM offers a standard-compliant implementation targeted at service providers only. It allows providers to switch traffic between 3G and WLAN (Wi-Fi Mobility), or redistribute it between available networks (Wi-Fi Mobility + IP Flow Mobility). To the best of our knowledge, there are no solutions that run on the client Smartphones and support both vertical and horizontal handover.

II. Problem Statement

Nowadays a smartphone is not just a luxury but a need. Every individual wants to have a prolonged battery life which lasts at least throughout the day, and higher bandwidth for a comfortable internet usage, which allows users to stay connected. When multiple access networks are available, the mobile devices supports both 3G networks and WLANs. Manually choosing access networks over and over again is tedious, some automatic 3G/WLAN handover solution is needed. The existing methods are more of a network connection based approach where, whenever there is a WiFi network available it switches from mobile data to WiFi, no matter how slow it is. The objective of this paper is to keep the battery and bandwidth under consideration, and switch between 3G and WLAN periodically at certain time intervals to ensure successful seamless handover that improves the Quality Of Service (QOS) of handheld devices.

III. Related Work

In this section we present the related works carried out by several authors.

In the paper [1] authors have proposed WiFiSenses, a system that employs user mobility information retrieved from low-power sensors (e.g., accelerometer) in smartphones and includes an algorithm to conserve Battery power which improves WiFi usage. Authors of [2] concentrate on offloading 3G network through WLAN, there by switching from one mobile network to another. This switching occurs if a new network is better than other network by a Network fitness criteria. Authors of [3] have proposed an algorithm based on the concept of dynamic boundary area seamless Inter-System Handover (ISHO) between 3G and WLAN, thereby reducing the power consumption associated by monitoring of 3G interface. The Download Booster in Samsung Galaxy S5 has improved connections that combines a Wi-Fi signal and a mobile signal. For consumers seeking an even faster connection, the Galaxy S5 now features Download Booster, a Wi-Fi technology for boosting data speed by bonding Wi-Fi and LTE simultaneously.

The authors of [4] have proposed an automatic handover mechanism which switches between 3G and WIFI based on the signal strength. This automatic handover of the network ensures steadier connection and faster downloading speed that improves Quality Of Service(QOS). Authors of [5] have proposed an accurate mobility model taking Soft Vertical Handover (SVHO) region into consideration. This prevents the Quality Of Service (QOS) degradation during vertical handoff in loosely coupled network. The paper [6] describes PowerBooter, an automated power model construction techniques that uses built-in battery voltage sensors and knowledge of battery discharge behavior to monitor power consumption while explicitly controlling the power management and activity states of individual components. Authors of [7] introduce network-based IP flow mobility model along with some experimental measures which shows how the usage of technology result in an extended battery life for the case of 3G and WIFI enabled terminals. The paper [8] reviews typical smartphone computing systems, energy consumption of smartphones and state-of-the-art techniques of energy saving for smartphones.

Most of the works carried out focuses on energy consumptions techniques, seamless Handover based on signal strength and energy conservation methods in smartphones. But these methods are more of a network connection based. Nowadays a smartphone is not just a luxury but a need. Every person wants to have a prolonged battery life which lasts at least throughout the day and the higher bandwidth for a comfortable internet usage, which allows users to stay connected. When multiple access networks are available, the mobile devices supports both 3G networks and WLANs. Manually choosing access networks over and over again is tedious. Therefore, some automatic 3G/WLAN handover solution is needed. The existing methods are more of a network connection based approach where, whenever there is a WiFi network available, the connection switches from mobile data to WiFi no matter how slow it is. The objective of our proposed paper is to keep the battery and bandwidth as parameters, and switch between 3G and WLAN periodically at certain time intervals to ensure successful seamless handover that improves the Quality Of Service (QOS) of handheld devices. In the Network Connection based approach, whenever there is a WiFi network available it switches from mobile data to WiFi. Such an approach does not consider metrics such as battery power of the phone and the bandwidth of the available network for a successful seamless handover.

IV. Proposed Model

In this section we present the proposed model. In our approach to the problem of handing over the network connection between the WLAN and 3G, we

take two parameters into account viz., Bandwidth and the Battery draining rate.
The initial assumptions made are:

- Both Mobile network and WLAN should be switched on.
- Wi-Fi networks are registered to the mobile phone with the password.

This is important because, switching takes place without the user interaction. In the proposed system, there are three components to perform the switching between networks, viz.,

- Swapper
- Analyzer
- Supervisor

Connections between the three components are shown in Fig.1.

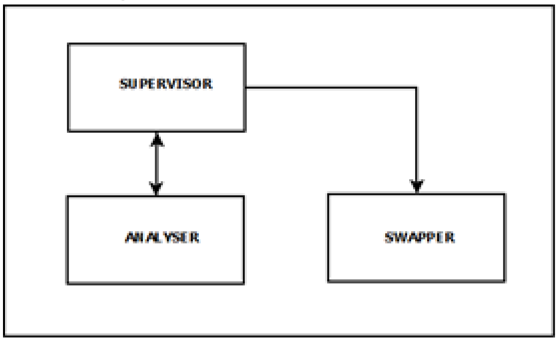

Fig.1: Core Components of the Proposed Model

Functions:

1. Swapper is the component responsible for the switching between 3G and WLAN accordingly, when specified by the supervisor. It switches between the two networks whenever necessary. Switching will be done dynamically.
2. Analyzer is the component responsible to find which of the two networks is better. This would be the one which will calculate the bandwidth of the two networks one after the other. It then determines the battery draining rate among the two networks, and returns the most efficient network that could be used, back to the supervisor.
3. Supervisor is responsible for supervising over the analyzer and swapper and giving then appropriate orders. The values returned by the analyzer would be taken as parameters and then the control is given to the swapper to achieve switching to the best network available at that point of time. Major concern is given to the evaluator which is responsible for evaluating and finding out the better network out of the two.

4.1 Interaction of Components

As the data rate of the two networks, 3G and WLAN would not be a constant value, there will be a periodic check of the bandwidth and the battery usage while using either of the two networks. When user starts to download, the supervisor would give the control to the analyzer to get the parameters which will be used to determine the efficient network. Bandwidth and Battery draining rate of the active network (3G/WLAN) is calculated. Then the same bandwidth and battery draining rate calculations are carried out for another network and returns those resulted parameters to the supervisor. By comparing the resulted values received from the analyzer, the efficient network is selected and the control is given to the swapper. The swapper, on receiving the control from the supervisor would switch to the appropriate network which would be efficient for a good Smartphone experience.

V. Algorithm

Algorithm 1: On energy efficient handover
Input: Current Battery Level, Transmission Rate, Download file size.
Output: Switching to the efficient Network.
Steps:

Remaining battery = (100 − Threshold battery level) − current battery level

if (Remaining battery ≤ Threshold) then
    Notify "Insufficient energy remaining"
    Switch to (WiFi , Dataconnection)
else
    EnergyForWIFI = ComputeEnergyRequired(wifi , transmissionrate)

    EnergyForDATA = ComputeEnergyRequired(Dataconnection, transmission rate)

end if.

Algorithm 2: On download Process
OnDownloadStart()
Remainingdownloadcapacity = Transmissionspeed / Remainingbatteryhours

if(RemainingdownloadSize > Remainingdownloadcapacity) then
    Notify "Insufficient energy remaining for downloading the file"
    Switch to (WiFi, Dataconnection)
else
    Startdownload( )
    Sleep(Remaining battery hour /2)
    return
end if.

Algorithm 1 shows energy efficient handover in heterogeneous network. The current battery level, Transmission rate and download file size are considered as input for the flow, which results in switching to efficient network. Constant threshold would be specified for the calculation of the remaining energy. The process starts with the calculation of remaining energy by comparing the current available energy with a given threshold. If the remaining energy is below the given threshold, it notifies about insufficient energy to continue the process and gets terminated. If the remaining energy is above threshold then the data rate and energy consumption is calculated for both WiFi and 3G as it indicates sufficient energy to continue the process. Once calculation is done then, the network with high data rate and low battery consumption will be selected and switched. As the user starts to download, the remaining energy is calculated to check whether there is sufficient energy to complete the download successfully. If not then, the downloading process gets terminated.

VI. Results and Discussion

In this section the tabulated results obtained after implementing the proposed system are discussed.

User Data in MB	Battery Level	Data rate in KBps	Current Mode	Switch Decision
3.5	53%	512	WIFI	WIFI(no change)
7.2	3%	512	WIFI	Turn-o (low battery)
3.5	69%	300	3G	WIFI
7.2	83%	912	3G	3G(no change)
7.2	5%	912	3G	Turn-o (low battery)

Table 1: Test Results.

Assumptions:

Data rate in actual criteria Broadband internet connections (WiFi) have superior data rates than a 3G network (that depends upon the data plans.). In some cases it might be opposite where there might be poor WiFi signal or a low speed internet. So, for testing purposes data rate values are multiplied so that switching can take place.

Battery level and Draining Rate: Battery parameters are the pivot of the switching process which might have different power factors for different devices. Our Testing devices include Samsung Galaxy Y and Galaxy Pocket: Li-Ion 1200 mAh battery, where other factors like background apps and services may contribute to draining rate.

The process starts with downloading the file with 3G as shown in the Fig. 2. We have intended to download a large file of size 7.2MB when the battery level is 83%, with the data rate of 912kbps.

Fig .2: Downloading from 3G.

In this case the Active network was 3G, the file size was 3.5MB and the remaining Battery value was 69% and the Switching was done in favor of WiFi as shown in Fig. 3.

Fig.3: Downloading from WiFi

The scenario in Fig. 4 below shows the switch to smart switch for downloading a file.

Fig .4: Downloading from smart switch

As we intended to download a larger file of size 7.2MB when the active connection was 3G with 83% of battery value, the smart switch was on 3G itself (Fig. 5) as it had 912 kbps of data rate where, the WiFi was limited to 128 kbps.

Fig.5: Smart Switch to 3G

The Fig. 6 shows the scenario where, the file size was 3.5MB and battery value was 53% which had the data rate of 512kBps and the WiFi was the Active network. And the Smart Switch decided to stay on WiFi on since the battery consumption is low with high bandwidth.

Fig.6: Smart switch to wifi

When the same 7.2MB file was tried to download in a 3G network of 912 KBps, both the networks were turned off by the application as the Battery level was at the threshold value (battery low).

Fig.7: Battery low status

The graph (Fig. 8) below shows the switching activity that takes place during the download of a file. The switchover is labeled along the graph. In this graph, X coordinate represents the battery level. And Y coordinate represents the user data that is download size of a file.

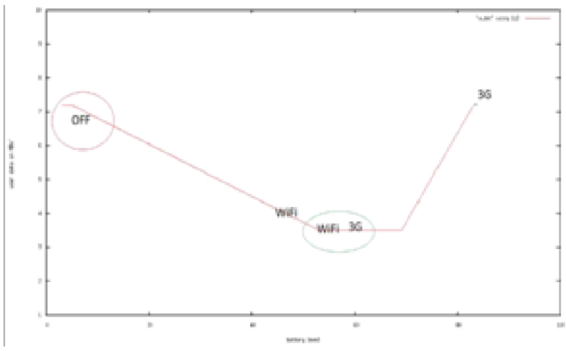

Fig.8: Battery vs Bandwidth graph

VII. Conclusion

We have presented a framework that enables switching from one network to another, automatically, scheduling them based on the two constraints: remaining energy and available bandwidth. The default method binds us to be connected to the Wi-Fi network no matter how slow it is. The automatic switching between 3G/Wi-Fi does not take place but we need to set it up in order to get faster connection. Through our framework, the best network is selected based on the constraints. Such selection of network ensures successful seamless handover by improving QOS (Quality Of Service), which has a positive impact on user's experience. The framework was tested on Android smartphones and the result shows that our proposed model is more efficient compared to the existing market.

Acknowledgements

I am thankful to those who have rendered their whole hearted support at all times for the completion of this paper.

References

[1] Shantidiv Mohanty, "*A New Architecture for 3G and WLAN integration and inter-system Handover Management*," *Springer Science + Business Media,LLC,pp.1--13, 2006.*

[2] Racha Ben Ali, Samuel Pierre, "*On the impact of Mobility and Soft Vertical Hando_ on Voice admission Control in loosely coupled 3G/WLAN Networks*," *IEEE Communications Letters,Vol. 13, 2009.*

[3] Lide Zhang, Birjodh Tiwana, Robert P.Dick, Zhiyun Qian, Z. Morley Mao, Zhaoguang Wang, Lei Yang, "*Accurate Online Power Estimation and Automatic Battery Behavior Based Power Model Generation for Smartphones*," *CODES+ISSS'10, Scottsdale, Arizona,USA ,Oct 2010.*

[4] WiFi Handover between access points not happening automatically, *2010.*

[5] kyu-Han Kim , Alexander W. Min , Dhruv Gupta , Prasant Mohapatra, Jatinder Pal Singh, "*Improving Energy E_ciency of Wi-Fi Sensing on Smartphones*,' ' *INFOCOM , proceeding IEEE,.pp.--09, 2011*.

[6] Nickolay Amelichev, Kirill Krinkin, "*Simulation of 3G/WLAN offload First Steps*," *8th conference of FINNISH-RUSSIAN University cooperation in Telecommunications,.pp. 9--19, 2011*.

[7] Nickolay Amerlichev, Kirill Krinkin, T.N. Nagabhushan, S.P. Shiva prakash, "*Signal Strength-Based approach for 3G/WLAN Handover on Nokia N900 Devices*," *proceeding of the 10th Conference of FRUCT Association,.pp.10--15, 2011*.

[8] WiFi AP Handover/Switching,'-'http://androidforums.com/captivate-all-things-root/270139-wi_-AP-handover-witching.html, *2011*.

[9] M. Isabel Sanchez, Carlos J. Bernardos and Antonio De La Oliva, Pablo Serralo, "*Energy Consumption savings with 3G Offload*," *Vehicular Technology Conference(VTC),IEEE 78TH,las vagas,.pp.1--5, 2013*.

[10] Feng Xia, Ching-Hsien Hsu, Xiaojing Liu, HaiFeng Liu and FangweiDing, Wei zhang, "*The Power of Smartphones*".