Essay: QoS Aware Voice Offloading In Heterogenous Network For VoIP

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Abstract – This Wireless Heterogeneous Networks (HetNets) are considered as one of the recent idea in next generation mobile networks. HetNets aim to increase the network capacity to meet the high data demand of mobile users. In Het- Nets, voice flow can be offloaded to unlicensed bands (Wi-Fi) to free some of the resources of the licensed bands (WiMAX). However, it needs to be guaranteed that the Wi-Fi can provide the needed Quality of Service (QoS) for the VoIP service. In this paper, we propose QoS-aware WiMAX/Wi-Fi offloading schemes that to maximize the utilization of the Wi-Fi hotspots by considering the network loading conditions and maintaining the required QoS for the VoIP.
I. INTRODUCTION

The growth of mobile data traffic has been explosive in recent years, driven, in particular, by the increased popularity of Smart phones. All over the world, cellular operators are struggling to cope with the rapid increase of traffic on their data networks. As cellular networks become overloaded, the quality of service available to customers is reduced; leading to customer dissatisfaction and rising churn rates. This challenge, along with the additional demand for providing service to locations where there is no or poor cellular coverage, is being overcome with a number of solutions. The most common of these are the deployment of femtocells and the use of Wi-Fi.

Femtocells are small cellular base stations meant for deployment within private homes or businesses. They typically support 2-4 phones in a residential environment and up to 16 phones in a business arena. Among the benefits of femtocell deployments for end users are better reception, lower battery consumption and improved voice quality.

While femtocells represent a pure cellular solution to the problem of cellular offloading, the use of Wi-Fi is becoming attractive for several reasons. Wi-Fi technology is not restricted by the use of licensed spectrum wavelengths. While femtocells are only deployed in private, indoor environments, Wi-Fi hotspots can be implemented in public or private networks and both indoors and outdoors. Furthermore, the Wi-Fi allows the operators to use existing residential and business networks with no need for subscribers to invest in new equipment.

Wi-Fi offloading seems the most viable solution at the moment. Building more Wi-Fi hotspots is significantly cheaper than network upgrades and new installations. Many users are also having their own Wi-Fi Access Points (APs) at homes and work. If a majority of traffic is redirected through Wi-Fi networks, carriers can accommodate the traffic growth only at a far lower cost. Given that there is already a widespread deployment of Wi-Fi networks, Wi-Fi offloading addresses the ‘time-to-capacity’ issue for the currently pressing need of additional network capacity.

There are two types of offloading: on-the-spot and delayed. On-the-spot offloading is to use spontaneous connectivity to Wi-Fi and transfer data on the spot. Most of the current Smartphone’s support on-the-spot offloading by default. In delayed offloading, each data transfer is associated with a deadline, and the data transfer is resumed whenever getting in the coverage of Wi-Fi until the transfer is complete.

On the spot offloading for the VoIP strongly affects its call quality, when it gets the Wi-Fi signal. Thus in this paper, we propose a QoS-aware VoIP offloading algorithm to maximize the utilization of the Wi-Fi interface, mean while maintaining the required QoS. Maximizing the Wi-Fi utilization in turn reduces the transmission cost. The main contributions of this paper are as follows. We develop a WiMAX/Wi-Fi HetNet simulation environment. Then, we propose a QoS-aware offloading scheme, which switch the users to either the WiMAX or the Wi-Fi interface, depending on the network loading condition. The proposed scheme utilizes the Wi-Fi interface upto the limit it can guarantee the required QoS.

This paper is organized as follows: We briefly review related work in Section 2. We then present the simulation model and formulate the problem in Section 3. In Section 4, we propose the QoS aware offloading algorithm. We implement the heterogeneous simulation environment in Section 5. In Section 6, we estimate the performance of the proposed algorithm through simulations and then conclude.

II. RELATED WORKS

This section reviews the existing literatures for offloading the data to other networks.

Kyunghan Lee provides a Quantitative study on the performance of 3G mobile data offloading through Wi-Fi networks. They present a trace-driven simulation using indicating that Wi-Fi already offloads about 65% of the total mobile data traffic and saves 55% of battery power without using any delayed transmission A distribution model-based simulator and a theoretical framework that enable analytical studies of the average performance of offloading were proposed. The tools provided by them are useful for network providers to obtain a rough estimate on the average performance of offloading for a given Wi-Fi deployment condition.

Lu Xiaofeng proposes a Subscribe- and-Send architecture and an opportunistic forwarding protocol called HPRO. Under Subscribe-and-Send, a user subscribes contents on the Content Service Provider (CSP) but does not download the subscribed contents. Some users who have these contents deliver them to the subscribers through Wi-Fi opportunistic peer-to-peer communications. Numerical simulations provide a robust
Sok-Ian Sou proposes an enhanced Wi-Fi offloading model to bring mobile Internet Protocol (IP) integration to a core network with PCC. They develop a comprehensive analytical model to quantify the performance of data offloading concerning the amount of 3G resources saved by offloading and the deadline assurance for measuring the quality of user experience with PCC support. Numerical results demonstrate that deadline assurance can be satisfied while saving a significant amount of 3G resources in many situations.

Bo Han, Pan Hu propose to exploit opportunistic communications to facilitate information dissemination in the emerging Mobile Social Networks (MoSoNets) and thus reduce the amount of mobile data traffic. They investigate the target-set selection problem for information delivery and provide a study on how to select the target set with only $k$ users, such that we can minimize the mobile data traffic over cellular networks. They have proposed three algorithms, called Greedy, Heuristic, and Random, for this problem and evaluate their performance through an extensive trace-driven simulation study.

Yongmin Choi presents a quantitative survey of mobile data traffic surge and a strategic solution to traffic offloading. The effect of a network strategy deploying multiple wireless networks was examined the relationship between the spread of smart phones and their contribution to the mobile data traffic surge. To see how mobile data traffic is transferred among different networks, they illustrate the traffic trend of the 3W (WCDMA, WIBRO, and Wi-Fi) network. Based on the composition of traffic, they also discuss functions and roles of the 3W networks in accessing mobile Internet. From these results, they show that deploying multiple wireless networks is an effective way of traffic offloading.

An Chan investigates several solutions to improve the VoIP capacity. Based on a conflict graph model, they propose a clique-analytical call admission scheme, which increases the VoIP capacity by 52 percent from 1.63 to 2.48 sessions per AP in 802.11b. They use coarse-grained time-division multiple accesses (CoTDMA) in conjunction with the basic 802.11 CSMA to eliminate the performance-degrading exposed-node and hidden-node problems in 802.11. A two-layer coloring problem (which is distinct from the classical graph coloring problem) is formulated to assign coarse time slots and frequency channels to the VoIP sessions, taking into account of the traces of the carrier-sensing operation of 802.11. Their findings show that CoTDMA can further increase the VoIP capacity in the multi-WLAN scenario by an additional 35 percent, so that 10 and 58 sessions per AP can be supported in 802.11b and 802.11g, respectively.

Fathi.H. focuses on the network layer mobility, specifically on mobile Internet Protocols (MIPs). Using analytical models, the authors evaluate MIPv4, MIPv6, fast MIPv6 (FMIPv6), and hierarchical MIPv6 (HMIPv6) and compare their performances in terms of handover delay for VoIP services. To optimize the handover delay, the authors propose to use the adaptive retransmission timer described in this paper. The results obtained using the adaptive timer technique show that for a 3% frame error rate and a 128-kb/s channel, the handoff delay is about 0.075 s (predictive) and 0.051 s (reactive) for FMIPv6. It is around 0.047 s [intra-mobile anchor point (MAP)] and 1.47 s (inter-MAP) for HMIPv6, around 1 s for MIPv6, and 0.26 s for MIPv4.

Thus the recent literatures concentrates on the general data, they did not focus on the delay that will incur on the VoIP calls, which is our motivation of our paper which will be explained in the following section.

III. WIMAX TO WI-FI OFFLOADING SIMULATION MODEL WITH QOS AWARE SCHEME FOR VOIP

In this section, we describe the simulation model of HetNets and the QoS degradation problem in VoIP we propose to solve.

A. Model of offloading in HetNets

In offloading, the goal is to redirect Internet traffic toward a low-cost access radio network like Wi-Fi to alleviate data congestion thereby delivering positive user experience.

Fig. 1 shows our proposed Voice offloading model with WiMAX and Wi-Fi HetNet environment. In this model the users are available to WiMAX and Wi-Fi hotspots, WiMAX being in licensed spectrum it will incur charges to the user, but in other hand Wi-Fi being an unlicensed spectrum technology is free of cost which is made available in many hotels and office. Thereby reducing the load on the primary cellular network like WiMAX and also reduces the bills from the Internet Service Provider (ISP) for the user by utilizing Wi-Fi for large size data upload and download.

Fig. 1. Voice offloading HetNet model.

To implement and analyze the Voice offloading with QoS aware strategy, we develop a WiMAX and Wi-Fi
enabled HetNet environment using Opnet. So that we can create and simulate a real time traffic and analyze the voice offloading technique.

Fig. 2. Opnet based model for WiMAX to Wi-Fi offloading.

Fig. 2 illustrate a HetNet environment with a Base Station of WiMAX, Access points (AP) for Wi-Fi hotspots in the cells, VoIP server to generate VoIP traffic, Server backbone and IP backbone. Other than the User Equipment with both WiMAX and Wi-Fi enabled all equipments are available in the OPNET object library. The User Equipment with both WiMAX and Wi-Fi capabilities that can receive data over both technologies can be developed by editing the node model of and replace it with the existing node model for User Equipment as shown in the Fig. 3.

As given in the Fig.3, the upper layers until IP node remain same as in the existing UE. The Address Resolution Protocol (ARP) and Media Access Control (MAC) layers are included for both WiMAX and Wi-Fi interfaces. The difference between WiMAX and Wi-Fi is that in WiMAX MAC each type of application is provided a specific class which corresponds to the needed QoS but in Wi-Fi MAC layer uses contention access to the user Equipment.

Fig. 3. Node model view of the WiMAX and Wi-Fi enabled User Interface with QoS aware offloading design.

The UE is designed with a Decision Layer to decide either to activate the WiMAX or the Wi-Fi interfaces by testing the load on the links. First we test the performance of the designed UE with both WiMAX and Wi-Fi capabilities by making VoIP calls. The QoS of VoIP can be evaluated and measured in terms of Mean Opinion Score (MOS), which is the scale given to determine the voice quality depending upon the user experience with the call. The VoIP call can be made using either WiMAX or Wi-Fi in this scenario to test the ability of the UE. Fig. 4 shows the performance of WiMAX ON for the VoIP showing a MOS value of 3, which denotes good user experience. Similarly the performance with Wi-Fi enabled for the VoIP showing a MOS value of 3 is shown in the figure 5. The load on both interfaces indicates which interface is activated for the particular time period. Thus the WiMAX and the Wi-Fi achieves the same MOS value. Fig. 5 depicts that if the VoIP application is the only traffic in the network, offloading to Wi-Fi will not degrade the MOS than that of WiMAX. In such scenario, traffic offloading from WiMAX to Wi-Fi should happen immediately once Wi-Fi is available. However, there might be some additional traffic in the HetNet that make us to analyze its performance with increased load during offloading which will be dealt in the following next sections.

Fig. 4. Performance measure with WiMAX interface ON.

Fig. 5. Performace measure with Wi-Fi interface ON.

B. Motivation and Problem Statement

Explosive surge in mobile data traffic has caused unprecedented pressure on the limited spectrum of cellular networks, pushing them to capacity limits in many geographical areas. The current literatures focuses only on data offloading, they did not consider the sensitive real time traffic like VoIP and how they affect the QoS of VoIP. The worst Quality of Service will be experienced by the user is in the midst of the VoIP call when the offloading occurs automatically.

As VoIP is highly QoS sensitive, offloading it to Wi-Fi as soon as it available causes degradation of the quality. Therefore there must be a certain procedure followed for offloading the voice application, which was the motivation of our paper.

The difference between the WiMAX and the Wi-Fi is that the consideration of the QoS classes. In WiMAX each type of application is assigned a specific class to meet the needed QoS for that application. Different traffic types with varied QoS class, for example our application of focus VoIP which have high QoS requirement are assigned with high priority for the resources, compared to other traffic types which are treated equally with best effort traffic class. They utilize the fact from the multiple access schemes like Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). Thus in Wi-Fi there is no distinction between the real time applications and non real time ones which sets the priority for the application. The user can avail the Wi-Fi only in competitive basis with other user. These issues on Voice calls will degrade the performance of the VoIP over Wi-Fi if the network gets congested.

To analyze these issues we develop a scenario in which the Wi-Fi and WiMAX are tested on the increased load conditions of about 3Mbps. Fig. 6 show the effect of increased load on WiMAX, where the MOS value remains unaffected for the Voice call due to the priority given for VoIP application in WiMAX and also number of users for a particular area is limited by the Internet Service Providers (ISP). But there is a serious
degradation of MOS value which fluctuates from 3 to as low as 1.5 MOS value when the load is as high as 3Mbps for the Wi-Fi as shown in the Fig.7 because the user has to compete for the resources with any number of users connected to the Wi-Fi access point at that particular time irrespective of the type of traffic thus making the VoIP quality less by competing with other data traffic.

Fig. 6. Performance of WiMAX during VoIP call.

Fig. 7. Performance of Wi-Fi during VoIP call.

Thus from the result obtained it is clear that the offloading from WiMAX to Wi-Fi should not happen automatically as soon as the User Equipment enters into Wi-Fi hotspots mainly for VoIP. The traffic on the Wi-Fi should be measured before offloading the voice data. So we develop a QoS-aware voice offloading scheme which will help the user to have an high quality voice call even if they are in a HetNets.

C. QoS-aware Voice Offloading Scheme for WiMAX to Wi-Fi

The algorithm for the QoS aware Voice offloading scheme is represented by the flowchart as shown in the Fig. 8. The UE checks the available signals. If there is a Wi-Fi hotspot available it checks the load of the Wi-Fi interface to a threshold value. It offloads to the available Wi-Fi hotspot if the load is less than the threshold value or else it will continue using the WiMAX interface. If the load in the Wi-Fi is greater than the threshold value, it will not be able to guarantee the required QoS of the VoIP

Fig. 8. QoS aware Voice Offloading algorithm flowchart.

The designed algorithm is tested with the OPNET simulation. In this the UE has the access to both Wi-Fi hotspots and WiMAX. The algorithm is tested under the heavy and normal loading conditions, so that we can maintain high MOS value for the VoIP and reducing the cost and the network traffic for ISP’s by utilizing the available Wi-Fi hotspots.

Fig. 9. Performace of Wi-Fi during voice offloading under normal load.

As shown in Fig. 9 the Wi-Fi interface is activated and the MOS is maintained at high value when the load is normal which will not affect the QoS of VoIP. However, when the load on the Wi-Fi is higher than the threshold value the WiMAX is used and the MOS value is maintained instead of automatically offloading to Wi-Fi network when there is heavy traffic and degrading the MOS value in turn reducing the Quality Of Service of VoIP.

Fig. 10. QoS maitained for VoIP under heavy load condition by enabling WiMAX.

IV. CONCLUSION AND FUTURE WORK

This paper presented the issues in offloading the Voice calls in the HetNets and proposed QoS-aware voice offloading for VoIP. We have developed a WiMAX/Wi-Fi based HetNet simulation environment and shown that the Wi-Fi degrades the VoIP quality on automatic offloading for the Voice application like VoIP when there is a heavy load. The WiMAX is used to preserve the high quality when here is a high load and guarantee the needed QoS. Therefore, we have proposed a QoS-aware voice offloading algorithm that will decided whether to offload to the Wi-Fi or to continue the WiMAX usage, based on the data rate, thereby reducing the cost and reduce the resource battle on the licensed spectrum.

The future work is to develop a SIP based Soft ‘Phone application, in which the SIP user agents that are embedded in the Smart-Phone as an application. This application is invoked when the user tries to make a call and the mobile phone is configured to use the SIP client for calls over a Wi-Fi data network and making them available on mainstream platforms such as Android, IOS and Windows 8 Mobiles.

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