International Conference on Advances in Management and Technology (iCAMT - 2013)
Proceedings published in International Journal of Computer Applications® (IJCA) (0975 – 8887)

Performance Analysis of Vertical Handover between Heterogeneous Networks

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ABSTRACT

For the development of the 4G wireless networks the design of seamless and efficient Vertical handovers is an essential issue. Next generation wireless communications will likely rely on integrated networks consisting of multiple wireless technologies. So the integration of WiMAX with other wireless technologies, such as WLAN, Wi-Fi, UMTS or 3G, has attracted research community for the last few years. With the recent introduction of mobility management frameworks in the IEEE 802.16e standard, the performance largely depends on the capability of performing fast and seamless handover between heterogeneous networks. Seamless vertical handover between different access technologies is a great challenge as it needs to obey different performance constraints. This research work aims to analyze performance of vertical handover between different access technologies in terms of low packet loss and minimum latency.

General Terms

WiMAX, Wi-Fi, UMTS, Handover, Delay, Mobility, QoS.

1. INTRODUCTION

The handoff is a process during which a mobile station (MS) immigrates from air interfaces for its current base station (BS) to air-interfaces of adjacent BS. With the recent introduction of mobility management frameworks in the IEEE 802.16e standard, WiMAX is now placed in competition to the existing and forthcoming generations of wireless technologies for providing ubiquitous computing solutions. However, the success of a good mobility framework largely depends on the capability of performing fast and seamless handovers irrespective of the deployed architectural scenario [9].

Handoff is an important process of mobility support in wireless network. Handoff is unavoidably incurred when a cell is overloaded or a MS moves out of a BS`s signal coverage. Therefore, mobile WiMAX allows both the MS and the network are allowed to do initial handoff like a 3G cell network where the network is always responsible for initiating a handoff [5].

Handovers can be divided into two types: Horizontal handovers and Vertical handovers. Horizontal handovers are homogeneous intra-network inter-cellular while the vertical ones are heterogeneous inter-network inter-cellular. For example, handovers between multiple WiMAX networks are horizontal, whereas those between WiMAX and 3G or WLAN networks are vertical.

Next-generation wireless network is striving to integrate different wireless access networks such as WiFi, WiMax, 3G, GPRS, UMTS to achieve a ubiquitous computing environment. Hence heterogeneous wireless networks have to cooperate in providing users with better quality of service (QoS) and seamless mobility. For the development of the 4G wireless networks the design of seamless and efficient Vertical handovers is an essential and challenging issue.

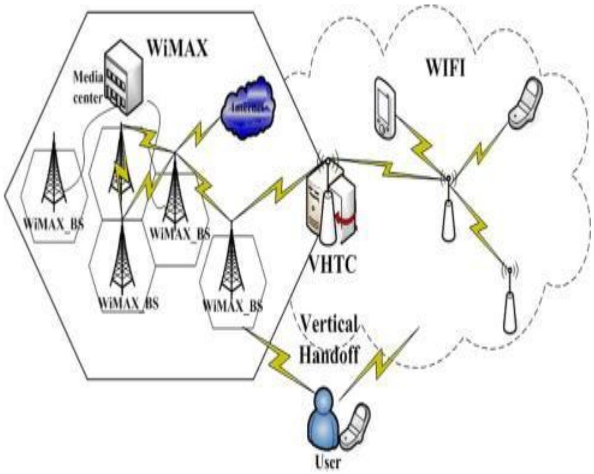

Figure 1: Vertical and horizontal handover in heterogeneous network [13].

2. VERTICAL HANDOVER

Vertical handover is a network that automatically changes its connection type to access a supporting infrastructure. When a computing device could connect to the Internet via two different network technologies, it is automatically connected to the available network. This shuffling or changing from one network to the other is the vertical handover.

For a vertical handover to occur, the following must be considered:

- A vertical handover supported device must contain a dual card to connect the two different wireless networks.

- With vertical handover, two wireless technologies are compared by means of handover-metrics. The wireless technology with the better handover metric is preferred.

- User requirements and preferences, relative-signal strength, overall network conditions and costs are major factors for the handover decision [4]There are three major guidelines in designing VHO solutions between heterogeneous networks. First, the solution should not require significant changes to legacy systems since service providers do not want their existing systems to be modified due to cost and complexity. Second, the signalling process should be optimized because VHO is a time-consuming process that could result in significant data traffic loss. Third, an IP-based solution is preferred to facilitate internetworking of current network systems and for potential extension to other heterogeneous accesses [10].

QoS parameters are used to analyze the performance of WiMAX networks. The operation principle of QoS is to prioritize network traffic, that is, to ensure that the highest- priority packets get over the network as soon as possible. Although QoS cannot speed up packet transmission, it certainly contributes to the improvement of packet transmission [5]. Standard 802.16 supports five different service types: UGS, rtPS, nrtPS BE and Ertps shown in Table

1.

Table 1: Service flows supported in WiMAX [5].

QoS category	Applications	QoS specifications
UGS (Unsolicited Grant Service)	VoIP	Maximum sustained rate Maximum latency tolerance Jitter tolerance
rtPS (Real-time polling service)	Streaming audio and video	Maximum sustained rate Minimum reserved rate Maximum latency tolerance Traffic priority
ErtPS (Extended real-time polling service)	VoIP	Maximum sustained rate Minimum reserved rate Maximum latency tolerance Jitter tolerance Traffic priority
NrtPS (Non-real-time polling service)	File Transfer Protocol (FTP)	Maximum sustained rate Minimum reserved rate Traffic priority
BE (Best effort service)	Data transfer, Web browsing, etc.	Maximum sustained rate Traffic priority

2.1 VHO Management Scheme

VHOM scheme works on the MAC layer protocols of IEEE

802.16 standards. The major functions of VHOM include traffic measurement, network status detection, handoff decision, and connection transition. The functions are performed by four modules as illustrated in Fig. 2:

- **Traffic measurement module (TMM):** periodically measures the throughput of the network and provides reports

to the Handoff decision module (HDM).

- **Network condition detection module (NCDM):** detects the availability of possible networks and estimates the

performance of the available network.

- **Handoff decision module (HDM):** is the core component of VHOM. It gathers information from other modules and manipulates their operation. It decides the need to launch a

handoff decision process and selects the target network based on the available handoff policies.

- **Connection transition module (CTM):** transfers all the connections of the station from the serving network to the selected target network [8].

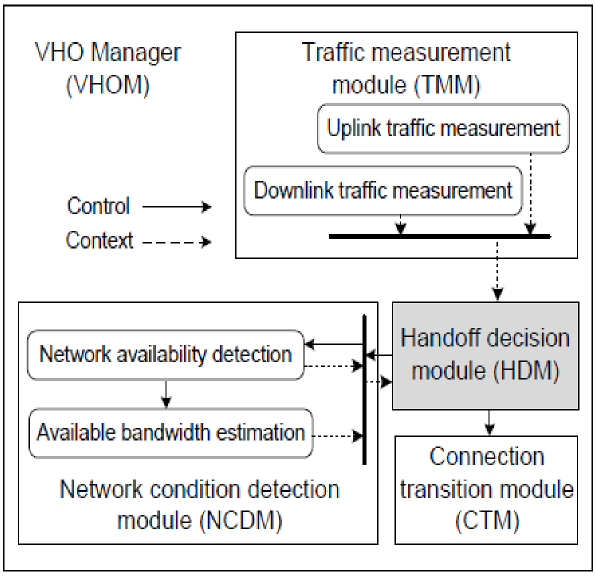

Figure 2: Overview of VHOM [8].

3. RELEATED WORK

3.1 Handover

A handover (HO) is when a phone call in progress is redirected from its current cell to a new cell. This normally happens when the mobile device making the call is in movement and detects that it is losing coverage, so it needs to "jump" to another antenna. In the Mobile WiMAX Networks, a handoff may cause the packet losses and service interruptions. Thus, handoff becomes one of the key issues determining the network performance.

The research issues related to potential handover in the existing and future WiMAX mobility framework was presented by Ray, S.K., et.al [9]. A survey of these issues in the MAC, Network and Cross-Layer scenarios is presented along with discussion of the different solutions to those challenges. A comparative study of the proposed solutions, coupled with some insights to the relevant issues, is also included. The result showed that cross-layer (L2+L3) have gained more attention than the solely layer 3 ones. They also suggested that cross-layer issues like seamless integration of L2 and L3 handover management messages and efficient bidirectional flow of these messages have been less visited than the other issues and need more attention in order to devise a good MWiMAX CLHM (Cross layer handover management) framework.

A work on an empirical study of the impact of traffic type, node mobility and handoff on the performance of a typical mobile WiMAX IEEE 802.16 network was proposed by Kangwook, B.J., et.al [5]. The objective of this work was to analyze WiMAX performance for small, medium and large network scenarios under FTP, HTTP, VoIP and Video conferencing traffic with varied node mobility (0~90km/h) through extensive simulation experiments. The performance is measured in terms of download/upload response time, object/page response time, jitter, MOS, PDV, end-to-end delay, depending on the traffic type being investigated and performance of mobile WiMAX is measured in terms of throughput and packet loss ratio.

The performance of handoff in a mobile WiMAX Network was studied by Vaidehi, V., et.al [11]. This paper revealed some challenges that mobile users face when travelling across different base stations in a Mobile WiMAX environment. One of the main goals when traversing between the networks, as a mobile user, is to ensure the loss of data or loss of connectivity does not occur as a result of handoff.

The latency during handoffs and the number of sent/received/dropped packets was examined. The simulator parameters were adjusted and their effects were noted. Additionally, after the adjustments, the parameters were kept constant and only the speed of MS was changed between 1-40 m/s, with 1 m/s step. The main task with simulations was to determine the parameters that had the greatest impact on the handoff latency when adjusted. As a result, some of the parameters did not influence the handoff times at all, but changing some of them even slightly had direct consequences. Significant impact was met by the parameters like changing velocity, Link Going Down factor, and different timeout & timer values such as the DLMAP (downlink parameter) timers.

3.2 Vertical Handover

When the HO is within the same technology, for example, between Wi-Fi cells, it is called a horizontal HO. If it is executed between different technologies, for example, WiMAX to Wi-Fi, then it is called vertical HO. Vertical HOs are typically executed between different operators and require a much more complex signaling.

The simulation of vertical handover between Wi-Fi and WiMAX was presented by Bhosale, S.K., et.al [2]. IEEE 802.21 was installed through NIST add-on modules. This standard was used to examine the mobility between Wi-Fi and WiMAX networks and to study its behaviour during handover

using the generated tracefile. Tracefiles were used by an open source software tool (Tracegraph Analyzer) to generate graphs. Tracegraph analyzer was used to analyze the behaviour of MN during handover with respect to packet loss.

It was seen that when a mobile node moved away from coverage area of one network and found better coverage in another network it undergo handover and started communicating via that network. During this process of handover it was seen from the graphs that handover affects different parameters, but the mobile node stay connected and the packet delivery continued even when the node moved away from the network coverage area. It was observed that the ratio of packet loss increases with the increase in the speed of MN.

A QoS scheme by applying the Signal to Interference and Noise Ratio SINR in vertical handover mechanism was proposed by Bathich, A.A., et.al [1] between WiMAX and Wi-Fi networks. In this paper, the Media Independent Handover MIH (IEEE 802.21) protocol was adopted to assist in the handover decisions by providing a suitable platform for vertical handovers. The result showed that the proposed SINR based vertical handoff decision (VHD) promote maximum achievable data rate and support QoS for different traffic flow & maximum downlink throughput.

A cross-layer optimization of vertical handover between mobile WiMAX and 3G cellular networks was proposed by Jaeho Jo, et.al [3]. This scheme reorders and/or parallelizes L2 and L3 signalling messages and reduces the number of signalling messages by combining L2 and L3 messages for vertical handover. The proposed scheme enhances the performance of vertical handover between mobile WiMAX and 3G networks in terms of low handover latency, high TCP throughput, and low UDP packet loss ratio.

Intersystem handover can be a solution to maintain the continuation of an ongoing session, where IP management is a key issue. Khan, M.M.A., et.al [6] discussed that the interworking between WiMAX and UMTS can be useful to get the benefits from both the systems and the handover between these two networks will make the end user connected whenever, wherever and for any services. This paper discussed the two most critical elements to be resolved for intersystem handover. An application layer issue is to provide continuity of an on-going session and network layer issue is to prevent the change of IP for a roaming user. IMS (IP Multimedia Subsystem) is used as a solution of the application layer issue and MIP (Mobile IP) is used as a solution of the network layer issue. To minimize latency and packet loss in the proposed method, soft handover is performed so that the mobile device has multiple interfaces to communicate with the different networks at the same time. Hence, the mobile device is assumed to have two transceivers; one for WiMAX interface and one for UMTS interface. IPv4 version of IP is used for IMS to eliminate the latency related to NAT. So there is no packet loss during handover in the radio path and the high latency in non overlapping area causes no effect on the service to the end user.

A MAV (Movement-Aware Vertical) handover algorithm was proposed by Wonjun Lee, et.al [12] to exploit movement pattern for avoiding unnecessary handovers in the integrated WLAN and Mobile WiMAX networks. To avoid unnecessary handovers, the MAV handover algorithm adjusts the dwell time adaptively and predicts the residual time in the cell of target base station (BS). The dwell time is defined as the amount of time over which a call is maintained within a particular cell. The simulation results showed that the MAV handover algorithm outperforms the fixed dwell timer scheme by eliminating the ping-pong effect and reducing unnecessary handovers.

Wireless technologies such as LTE, WLAN, WiMAX, etc were developed with different standards and these technologies offer variety of services, different data rates and diverse area of coverage. Nithyanandan, L., et,al [7] discussed one of the forthcoming challenge in network management, that is to grant connection between end to end heterogeneous wireless technologies.To provide such end to end connection between heterogeneous networks vertical handoff is performed. The term interworking is used to express interactions between heterogeneous networks with the aim of providing an end-to-end communication. In this work four different types of interworking architectures were designed between WLAN, LTE and WiMAX networks namely: tightly coupled integration, loosely coupled integration, tight coupling with neighbor reservation and with gateway relocation. Consideration of vertical handover is made by locating the mobile node in a region where WLAN, LTE and WiMAX coverage coexist. It was found that tight coupling with neighbour reservation and with gateway relocation provides better handover performance. The network simulation also showed that interworking architecture with gateway relocation outperforms the other coupling methodologies due to the reason that a secondary path is established prior to handover and it results in less handover delay, lesser packets dropped and high signal to noise ratio. It was found that handover delay is lesser than the voice inactivity time with neighbour reservation and with gateway relocation and hence assures that seamless connectivity can be achieved.

4. CONCLUSION

To resolve the intersystem handover, both application layer and network layer should be the points of focus for the service providers. But none of the available methods like 3GPP IMS, coupling, MIH (Media independent handover) and MIP (Mobile IP) deals with both the network and application

layers. In the proposed idea, IMS (IP Multimedia Subsystem) mainly manages the multimedia session in the application layer with SIP protocol and MIP works in the network layer with IP protocol during handover. Although the latency of handover is high in non-overlapping area, however mobile device with multiple transceivers able to maintain radio links between WiMAX and UMTS networks at the same time causes a make-before-break type of handover. Thus, when the handover process is going on through one transceiver, service continues through the other transceiver.

Consequently, one can conclude that use of both IMS and MIP simultaneously can provide a seamless intersystem handover between WiMAX and UMTS. So, the user is always connected to some network during handover which will cause minimum latency and no packet loss during handover but the user will experience a change in the service quality when moving from one network access to another.

5. ACKNOWLEDGMENTS

I thank Dr. Jyotsna Sengupta who guided me for this work with her support and encouragement throughout the research process. I further like to thank my family for their support, tolerance and encouragement during my work.

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