Simulation of Performance Execution Procedure to Improve Seamless Vertical Handover in Heterogeneous Networks

Omar Khattab and Omar Alani
School of Computing, Science & Engineering
University of Salford
Greater Manchester- M5 4WT,UK

***Abstract*— One challenge of wireless networks integration is the ubiquitous wireless access abilities which provide the seamless handover for any moving communication device between different types of technologies (3GPP and non-3GPP) such as Global System for Mobile Communication (GSM), Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX), Universal Mobile Telecommunications System (UMTS) and Long Term Evolution (LTE). This challenge is important as Mobile Users (MUs) are becoming increasingly demanding for services regardless of technological complexities associated with it. To fulfill these requirements for seamless Vertical Handover (VHO) two main interworking architectures have been proposed by European Telecommunication Standards Institute (ETSI) for integration between different types of technologies; namely, loose and tight coupling. On the other hand, Media Independent Handover IEEE 802.21 (MIH) is a framework which has been proposed by IEEE Group to provide seamless VHO between the aforementioned technologies by utilizing these interworking architectures to facilitate and complement their works. The paper presents the design and the simulation of a Mobile IPv4 (MIPv4) based procedure for loose coupling architecture with MIH to optimize performance in heterogeneous wireless networks. The simulation results show that the proposed procedure provides seamless VHO with minimal latency and zero packet loss ratio.**

Keywords—Vertical Handover (VHO); Media Independent Handover (MIH); Interworking Architectures; Mobile IPv4 (MIPv4); Heterogeneous Wireless Networks

I. INTRODUCTION

With the advancement of wireless communication and computer technologies, mobile communication has been providing more versatile, portable and affordable networks services than ever. Therefore, the number of Mobile Users (MUs) communication networks has increased rapidly. For example, it has been reported that "today, there are billions of mobile phone subscribers, close to five billion people with access to television and tens of millions of new internet users every year" [1] and there is a growing demand for services over broadband wireless networks due to diversity of services which can't be provided with a single wireless network anywhere anytime [2]. This fact means that heterogeneous environment of wireless networks, such as Global System for

Mobile Communication (GSM), Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX) and Universal Mobile Telecommunications System (UMTS) will coexist providing MU with roaming capability across different networks. One of the challenging issues in Next Generation Wireless Systems (NGWS) is achieving seamless Vertical Handover (VHO) while roaming between these technologies. Therefore, telecommunication operators will be required to develop a strategy for interoperability of these different types of existing networks to get the best connection anywhere anytime. To fulfill these requirements of seamless VHO two main interworking architectures have been proposed by European Telecommunication Standards Institute (ETSI); namely, loose and tight coupling for integration between the different types of technologies. On the other hand, Media Independent Handover IEEE 802.21 (MIH) is a framework which has been proposed by IEEE Group to provide seamless VHO between different technologies by utilizing the above interworking architectures to complement their works. The paper presents the design and the simulation of a MIPv4 based procedure for loose coupling architecture with MIH to optimize performance in heterogeneous wireless networks in terms of latency and packet loss. The results of the proposed procedure show that it can provide a seamless VHO with minimal latency and zero packet loss ratio.

The rest of the paper is organized as follows: section II describes the VHO management. In section III, related works are presented. In section IV, the proposed procedure is presented. In section V, the simulation results and discussions of the proposed procedure are presented and finally, the conclusion is included in section VI.

II. VERTICAL HANDOVER MANAGEMENT

The mechanism which allows the MUs to continue their ongoing sessions when moving within the same Radio Access Technology (RAT) coverage areas or traversing different RATs is named Horizontal Handover (HHO) and VHO, respectively. In the literature most of the research papers have divided the VHO management into three phases: Collecting Information, Decision and Execution (e.g., [3 and 4]) as described below.

Handover Collecting Information

In this phase, all required information for handover decision is gathered, some of this information is related to the user's preferences (e.g., cost, security), network (e.g., latency, coverage) and terminal (e.g., battery, velocity).

Handover Decision

In this phase, the best RAT based on aforementioned information is selected and the handover execution phase is informed about that.

Handover Execution

In this phase, the active session for the MU will be maintained and continued on the new RAT. After that, the resources of the old RAT are eventually released.

III. Related Works

In previous works, three surveys about VHO approaches proposed have been presented [5, 6 and 7].

In [5], the VHO approaches proposed in the literature have been classified into four categories based on MIH and IP Multimedia Subsystem (IMS) frameworks (MIH based VHO category, IMS based VHO category, MIP under IMS based VHO category and, MIH and IMS combination based VHO category) in order to present their objectives in providing seamless VHO. It has been concluded in [5] that the MIH is more flexible and has better performance providing seamless VHO compared with IMS framework. The IEEE Group has proposed MIH to provide a seamless VHO between different RATs [8 and 9]. The MIH defines two entities: first, Point of Service (PoS) which is responsible for establishing communication between the network and the MU under MIH and second, Point of Attachment (PoA) which is the RAT access point. Also, the MIH provides three main services: Media Independent Event Service (MIES), Media Independent Command Service (MICS) and Media Independent Information Service (MIIS) [10] such that the MIH relies on the presence of mobility management protocols (e.g., MIPv4 and MIPv6).

In [6], the VHO approaches proposed in the literature have been classified into two categories based on the mobility management protocols (MIPv4 and MIPv6) for which their performances and characteristics have been presented. It has been concluded in [6] that providing service continuity through MIPv4 category under MIH will allow the operators to diversify their access networks take into account advantages of this category while MIPv6 category under MIH requires future work improvements in terms of VHO decision criteria, additional entities, complexity, diversity of RATs and evaluation using empirical work real environment.

In [7], loose and tight coupling interworking architectures have been surveyed their objectives, features and challenges. It has been concluded in [7] that the loose coupling is more suitable with MIH and contributes for enhancing its vital role in heterogeneous wireless environment to get fast and soft seamless roaming with minimal latency and minimal packet loss, respectively. From previous works [5, 6 and 7], three vital things have been concluded as follows:

- MIH is more flexible and has better performance providing seamless VHO compared with IMS framework.
- MIPv4 category under MIH will allow the operators to diversify their access networks take into account advantages of this category while MIPv6 category under MIH requires future work improvements.
- Loose coupling is more suitable with MIH and contributes for enhancing its vital role in heterogeneous wireless environment (minimal latency and minimal packet loss).

As a result of the conclusions above, a procedure of loose coupling which could be applied in conjunction with MIPv4 under MIH has been proposed in [11 and 12]. In [12], analytical modeling results considering Wi-Fi and WiMAX scenario showed that the VHO latency and packet loss were significantly reduced compared with the procedures found in the literature: Proxy MIPv6 (PMIPv6), Proxy First MIPv6 (PFMIPv6) and MIH-enabled PMIPv6. The results in [12] showed that the proposed procedure outperformed the existing procedures and scored ($4.4x10^{-3}$ sec) and ($1.6x10^{-2}$) of latency and packet loss ratio, respectively.

IV. The Proposed Procedure

This section describes the proposed procedure through VHO phases: Initiation, Decision and Execution.

A. Initiation Phase

In this phase, while MU is connected to a source network the VHO procedure will be triggered imperatively due to Radio Signal Strength (RSS) going down or alternatively based on the user’s preferences (e.g., high data rate, low cost).

B. Decsion Phase

In this phase, as a result of triggering in the initiation phase, *MIIS Request/Response Available RATs* message will be responsible to pass available RATs to MU via source network (PoA and PoS). In imperative session due to RSS going down the MU will select RATs list of priority based on user’s preferences and then pass them to the destination PoS via source network whereas in alternative session the MU will select RATs list of priority based on user’s preferences due to his/her profile change.

When the first choice from RATs list of priority could not be satisfied with available resources, the Admission Control (AC) at destination PoS will automatically move to another RAT selection in the list in order to satisfy the requirements of this RAT selection and so on. Once RAT of sufficient resources has been found, it will be checked by destination PoS whether it is compliant with the rules and preferences of operators. If that is available, the MIIS/Home Agent (HA) will be informed to start buffering for new data packets which are sent by Correspondent Node (CN).

C. Execution Phase

In this phase, the MU will be connected to target RAT to start its Authentication, Authorization and Accounting (AAA) with destination PoA and obtain Care of Address (CoA) from Dynamic Host Configuration Protocol (DHCP).

After that, *Update/Acknowledge binding* message notifies HA about the new CoA to start sending the buffered data and continuing the session within target RAT, this is shown in Fig. 1.

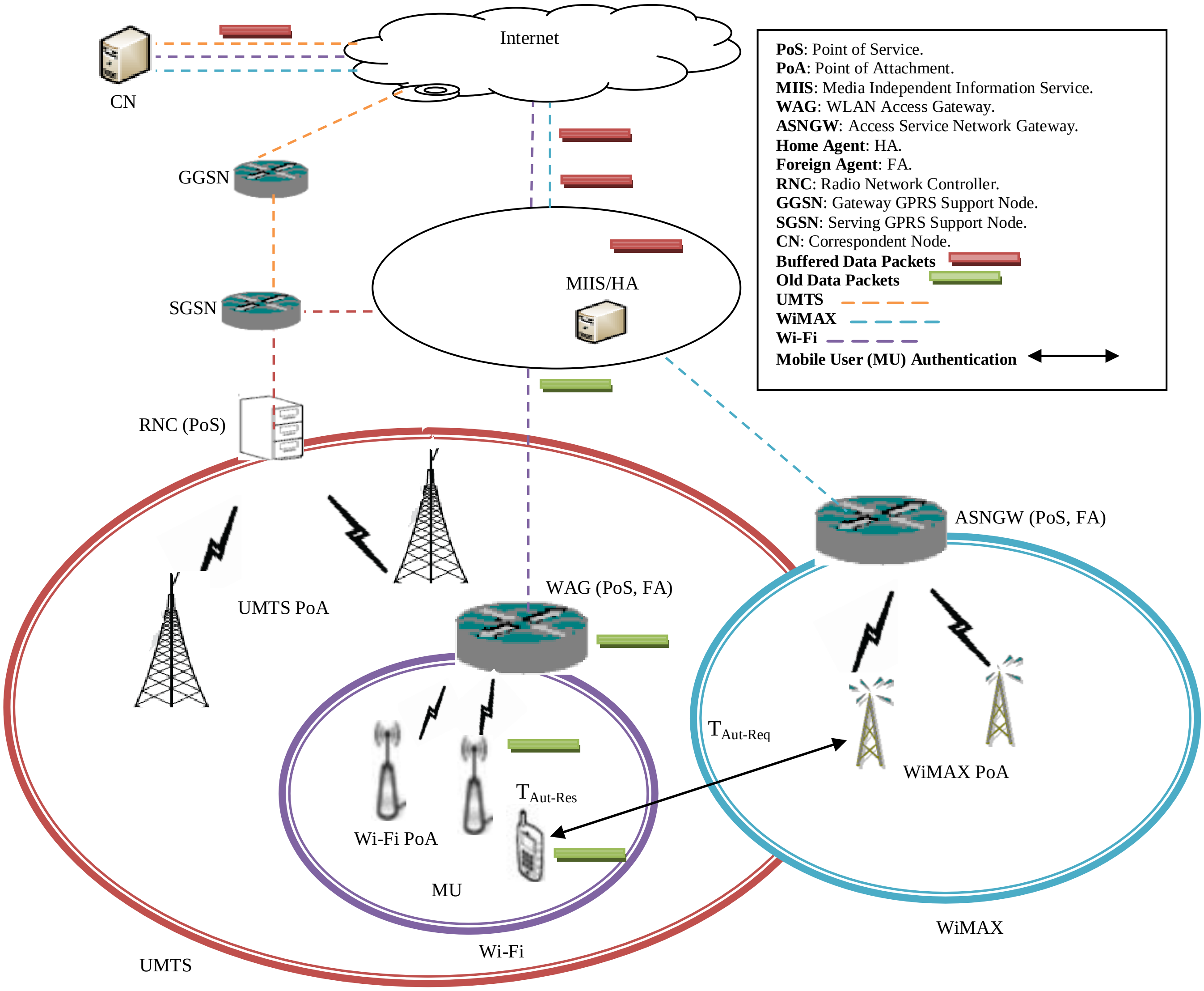

Fig. 1. Diagram of proposed procedure [12]

V. Simulation Results and Discussions

The latency and packet loss are the major drawbacks in the execution phase where this phase is out of the scope of MIH (e.g., handover signaling, context transfer and packet reception) [13]. Therefore, after the analysis of the results in previous work [12], the simulation has applied the proposed procedure of loose coupling in conjunction with MIPv4 taking into account the handover signaling time in the execution phase and RSS going down in order to make VHO decision. The MU originally is hosted by Wi-Fi and it has started moved toward the WiMAX and received VoIP traffic, this is shown in Fig. 2. Detailed characteristics of the simulation parameters are explained in TABLE I.

After the implementation of the proposed procedure in the specific scenario, Fig. 3 and Fig. 4 illustrate the proposed procedure with average latency of ($2x10^{-5}$ sec) and zero packet loss, respectively. The latency is the time taken for the MU to obtain a new IP address from a target network and register itself with HA [14]. During this process the MU does not receive any packets as a result of handover. The latency is the main cause of packet losses during handover [15]. Therefore, the results obtained in this simulation and the analytical modeling in previous work [12] show that the packet loss ratio improves as long as the latency reduced.

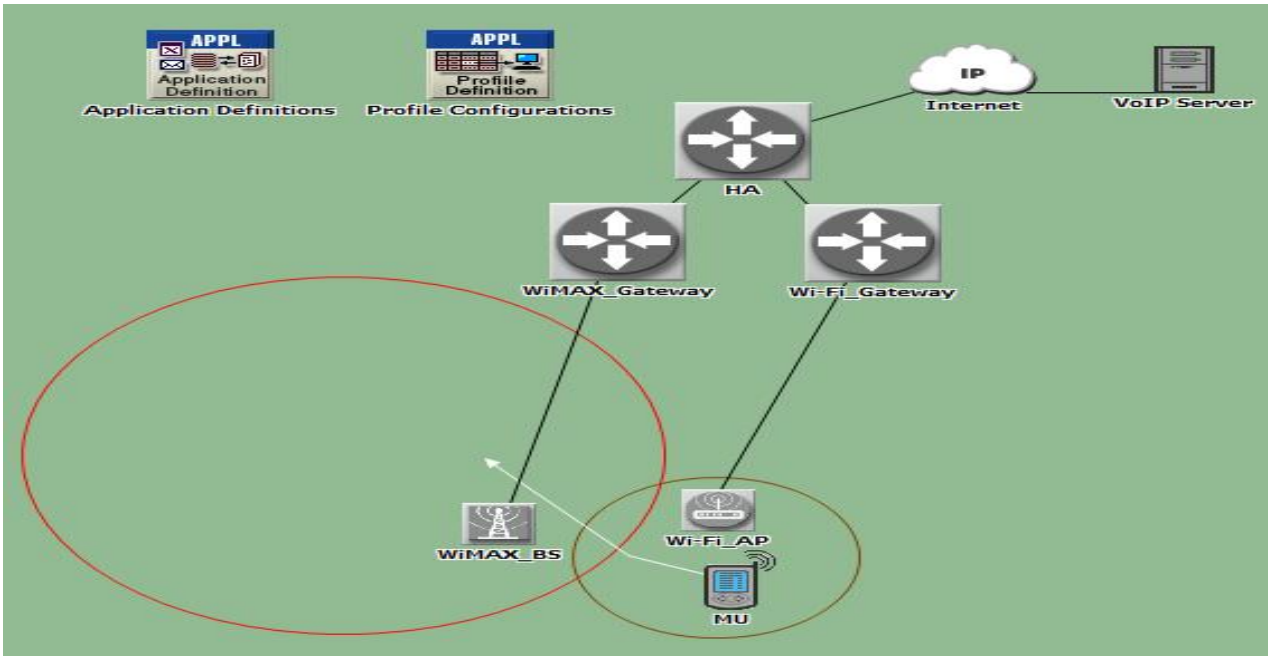

Fig. 2. Simulation diagram of proposed procedure from Wi-Fi to WiMAX

TABLE I. PARAMETERS FOR PERFORMANCE EVALUATION OF SIMULATION MODELING

Name of the Parameter	Value of the Parameter
Simulation Duration	60 minute.
Path (Trajectory)	Linear.
Mobile User Velocity	10 Km/hr.
Traffic	VoIP.
WiMAX	
Cell Coverage	Ellipse, width=1000 m, height=1000 m.
Maximum Transmission Power	0.1 W.
Physical Profile Type	OFDM.
Receiver Sensitivity	-200dBm.
Antenna Gain	15 dBi.
Wi-Fi	
Cell Coverage	Ellipse, width=450 m, height=450 m.
Transmit Power	0.0005 W.
Physical Profile	Direct sequence.
Packet Reception-Power Threshold	-95 dBm.
Data Rate	11 Mbps.

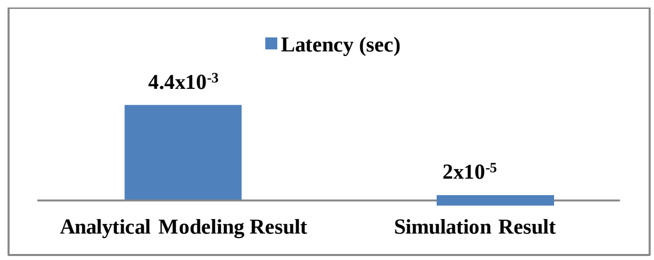

Fig. 3. Comparison of the proposed procedure performance using simulation result vs. analytical modeling result (latency)

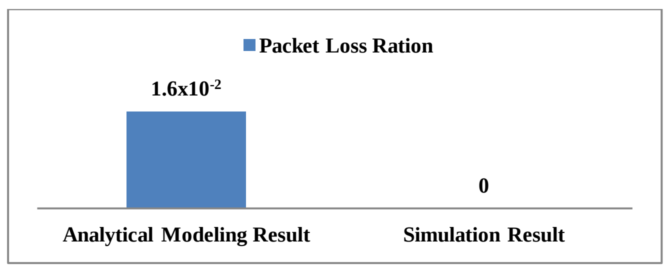

Fig. 4. Comparison of the proposed procedure performance using simulation result vs. analytical modeling result (packet loss)

VI. CONCLUSION

The paper has presented the design and the simulation of a MIPv4 based loose coupling architecture with MIH for providing optimized performance in heterogeneous wireless networks in terms of latency and packet loss.

The simulation results of the proposed procedure show that the VHO latency and packet loss are significantly reduced. In future work, a much more sophisticated and intrinsic scenarios are required which would take into account a wider array of parameters and MUs to make a more intelligent and optimized network selection.

REFERENCES

[1] Our vision: Committed to connecting the world. (2013). International Telecommunication Union (ITU). Retrieved 20 May, 2014, from http://www.itu.int/en/about/Pages/vision.aspx.

[2] B. Angoma, M. Erradi, Y. Benkaouz, A. Berqia, and M.C. Akalay, "HaVe-2W3G: A vertical handoff solution between WLAN, WiMAX and 3G networks," 7th International Wireless Communications and Mobile Computing Conference (IWCMC), pp.101-106, 4-8 July 2011.

[3] M. Louta, P. Zournatzis, S. Kraounakis, P. Sarigiannidis, and I. Demetropoulos, "Towards realization of the ABC vision: a comparative survey of access network selection," Symposium on Computers and Communications(ISCC), pp.472-477, 28 June 2011-1 July 2011.

[4] M. Zekri, B. Jouaber, and D. Zeghlache, "Context aware vertical handover decision making in heterogeneous wireless networks," IEEE 35th Conference on Local Computer Networks (LCN), pp.764-768, 10-14 October 2010.

[5] O. Khattab, and O. Alani, "A survey on Media Independent Handover (MIH) and IP Multimedia Subsystem (IMS) in heterogeneous wireless networks," International Journal of Wireless Information Networks, vol.20, no.2, pp.215-228, July 2013.

[6] O. Khattab, and O. Alani, "Survey on Media Independent Handover (MIH) approaches in heterogeneous wireless networks," 19th European Wireless 2013 (EW 2013), pp.1-5, 16-18 April 2013.

[7] O. Khattab, and O. Alani, "An overview of interworking architectures in heterogeneous wireless networks: objectives, features and challenges," 10th International Network Conference 2014 (INC 2014), 8-10 July 2014. Accepted 31 March 2014 and to be published after the Conference.

[8] P. Neves, J. Soares, and S. Sargento, "Media independent handovers: LAN, MAN and WAN scenarios," IEEE GLOBECOM Workshops, pp.1-6, 30 November 2009 –4 December 2009.

[9] G. Lampropoulos, A.K. Salkintzis, and N. Passas, "Media independent handover for seamless service provision in heterogeneous networks," IEEE Communication Magazine, vol.46, no.1, pp.64-71, January 2008.

[10] J. Marquez-Barja, C.T. Calafate, J.C. Cano, and P. Manzoni, "Evaluation of a technology-aware vertical handover algorithm based on the IEEE 802.21 standard," IEEE Wireless Communications and Networking Conference (WCNC), pp.617-622, 28-31March 2011.

[11] O. Khattab, and O. Alani, "I AM 4 VHO: new apprach to improve seamless vertical handover in heterogeneous wireless networks," International Journal of Computer Networks & Communications (IJCNC), vol.5, no.3, pp.53-63, May 2013.

[12] O. Khattab, and O. Alani, "Mobile IPv4 based procedure for loose coupling architecture to optimize performance in heterogeneous wireless networks," International Journal of Computer Networks and Wireless Communications (IJCNWC), vol.3, no.1, pp.56-61, February 2013.

[13] IEEE 802.21 Tutorial. (2006). IEEE 802.21. Retrieved 20 May, 2014, from http://www.ieee802.org/21/.

[14] S. Haseeb, and A.F. Ismail, "Handoff latency analysis of mobile IPv6 protocol variations," Computer Communications, vol.30, no.4, pp.849-855, 26 February 2007.

[15] Z. Liyan, Z. Li Jun and P. Samuel, "Performance analysis of seamless handover in mobile IPv6-based cellular network," In cellular networks - positioning, performance analysis and reliability, M. Agassi, Ed. Croatia: InTech, 2011, pp.305-330.