Improving Initiation Phase for Vertical Handover in Heterogeneous Mobile Networks

Dr. Omar Khattab

Abstract— *One challenge of wireless networks integration is to provide ubiquitous wireless access abilities and seamless handover for mobile communication devices between different types of technologies (3GPP and non-3GPP) such as Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX), Universal Mobile Telecommunications System (UMTS) and Long Term Evolution (LTE). This challenge is critical as Mobile Users (MUs) are becoming increasingly demanding for improved services regardless of the technological complexities associated with them. To fulfill these requirements for seamless Vertical Handover (VHO) two main interworking frameworks were proposed by IEEE Group and 3GPP for integration between the aforementioned technologies; namely, Media Independent Handover IEEE 802.21 (MIH) and IP Multimedia Subsystem (IMS), where each of them requires mobility management protocol to complement its work such as Mobile IP (MIP) and Session Initiation Protocol (SIP), respectively. This paper presents an improvement on the traditional Imperative Alternative MIH for Vertical Handover (I AM 4 VHO) algorithm for enhancing VHO in heterogeneous wireless networks environment. Finally, the numerical analysis of the improved algorithm shows lower VHO connection failure (probability of session rejection) compared to the traditional I AM 4 VHO algorithms.*

Keywords— *Vertical Handover (VHO), Media Independent Handover (MIH), VHO Connection Failure.*

I. INTRODUCTION

With the advancement of Radio Access Technologies (RATs), mobile communications has been more widespread than ever before. Therefore, the number of users of mobile communication networks has increased rapidly as an 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 [2-7]. This fact means that heterogeneous environment of wireless systems such as Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX), Universal Mobile Telecommunications System (UMTS) and Long Term Evolution (LTE) will coexist providing Mobile Users (MUs) 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 without interruption to the ongoing sessions. To fulfill these requirements for seamless VHO two main interworking frameworks were proposed by IEEE Group and 3GPP for integration between the different types of technologies; namely, Media Independent Handover IEEE 802.21 (MIH) and IP Multimedia Subsystem (IMS), where each of them requires mobility management protocol to complement its work such as Mobile IP (MIP) and Session Initiation Protocol (SIP). This paper presents an improvement on the traditional Imperative Alternative MIH for Vertical Handover (I AM 4 VHO) algorithm to provide lower VHO connection failure (probability of session rejection) for enhancing VHO in heterogeneous wireless networks environment. The rest of the paper is organized as follows; section II describes the VHO management, MIH and IMS frameworks. In section III, related works are presented. In section IV, an improvement on the traditional I AM 4 VHO algorithm is presented. In section V, numerical analysis for the improved I AM 4 VHO algorithm is presented. 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 RAT coverage areas or traversing different RATs is named Horizontal Handover (HHO) and VHO, respectively. In the literature VHO management is divided into three phases: Collecting Information, Decision and Execution [8-15] as described below.

- ***Handover Collecting Information***

In this phase, all required information for VHO decision is gathered, some related to the user 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.

A. Media Independent Handover (MIH)

The IEEE Group released IEEE 802.21 standard Media Independent Handover (MIH) in 2009 to provide seamless VHO between heterogeneous networks that include both wireless (3GPP and non-3GPP) and wired media [16-23]. IEEE 802.21 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 attachment point represents the network side endpoint connected to the MU. Also MIH provides three main services: Media Independent Event Service (MIES), Media Independent Command Service (MICS) and Media Independent Information Service (MIIS) [24].

- ***Media Independent Event Service (MIES)***

It is responsible for reporting the events after detecting, e.g. link up on the connection (established), link down (broken), link going down (breakdown imminent), etc. [25].

- ***Media Independent Information Service (MIIS)***

It is responsible for collecting all information required to identify if a handover is needed or not and provide them to MUs, e.g. available networks, locations, capabilities, cost, etc. [25].

- ***Media Independent Command Service (MICS)***

It is responsible for issuing the commands based on the information which is gathered by MIIS and MIES, e.g. MIH handover initiate, MIH handover prepare, MIH handover commit and MIH handover complete [25].

However, no handover decision is made within MIH [26], "the actual algorithms to be implemented are left to the designers" [27] and implementation of the decision algorithm is out of the scope of MIH [17].

B. IP Multimedia Subsystem (IMS)

The IP Multimedia Subsystem (IMS) was introduced in 2002 by 3GPP (Released 5) to support multimedia services in UMTS [28-31] and provide access security to IMS. However, it started supporting multimedia service for both wireless (3GPP and non-3GPP) and wired networks in Release 7 [32]. The IMS is defined as a 3-layer architecture consisting of transport layer, control layer and application layer.

- ***Transport Layer***

It includes all the entities for the supported access networks which allow IMS devices and MUs connect the IMS through many types of access networks, e.g. UMTS, Wi-Fi, WiMAX, etc, also it allows the IMS device to receive/send call either through the Public Switched Telephone Network (PSTN) or the Media Gateway (MGW) [33].

- ***Control Layer***

This layer includes three SIP signaling servers that are known as Call-Session Control Functions (CSCFs) which are responsible for establishing, managing and terminating media sessions, also it includes other entities: Home Subscriber Service (HSS), Breakout Gateway Control Function (BGCF), Media Gateway Control Function (MGCF), Media Resource Function Controller (MRFC) and Multimedia Resource Function Processor (MRFP) [33].

- ***Application Layer***

In this layer the application server is responsible for hosting and executing all the services offered by IMS.

However, in this framework handover decision is out of its scope and unlike the MIH framework, the MU obliges to discover neighbor cells with no assistance from the network by periodically conducting a radio scanning in the background which a results in: (a) Limited information is discovered (b) The MU needs two receivers work concurrently one for scanning and another for ongoing session while one receiver may be incurred probability of missing data from serving cell (c) Higher MU power consumption and (d) Upgrades legacy cells (2G/3G) due to broadcast information about 4G neighbors cells such as WiMAX and LTE.

III. Related Works

In [34], the VHO approaches proposed in the literature have been classified into four categories based on MIH and 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 [34] that MIH is more flexible and has better performance providing seamless VHO compared with IMS framework; hence, the majority of approaches in the literature were based on MIH framework.

In [35], the VHO approaches proposed in the literature have been classified into three categories based on MIH and Access Network Discovery and Selection Function (ANDSF) which works as a store of RATs information such as information about neighbor cells, operator's policies and preferences (ANDSF based VHO category, MIH based VHO category and

MIH and ANDSF combination based VHO). It has been concluded in [35] that the VHO approaches concentrated primarily on packet loss and latency whereas VHO connection failure and signaling cost have not been considered thoroughly.

In [36], the traditional I AM 4 VHO algorithm has been proposed in the decision phase based on MIH framework to achieve: (a) low VHO connection failure (probability of session rejection) and (b) low signaling cost.

The probability of handover connection failure occurs when the handover is initiated but the target network does not have sufficient resources to complete it (session rejection due to unavailable resources) or when the MU moves out of the coverage of the target network before the process is finalized [37]. There are many existing VHO approaches have been proposed in the literature to reduce VHO connection failure [36, 38-45]. The VHO approaches in [38-45] have considered only the MU's moves as the handover connection failure factor while the other work in [36] has contented only with the session rejection factor.

IV. Improving Initiation Phase For The Traditional I am 4 Vho Algorithm

From the section above it was concluded that the approaches in [36, 38-45] have only either concentrated on MU's moves as the handover connection failure factor or they have contented with the session rejection factor. In the recent approach [36], the traditional I AM 4 VHO algorithm has been proposed in the decision phase to achieve: (a) low VHO connection failure (probability of session rejection) as a result of using the optimum RATs (list of priority) and (b) low signaling cost. The algorithm has defined two main types of VHO: Automatically Imperative VHO (AIVHO) session and Alternative VHO (AVHO) session. The AVHO consists of Automatically Alternative VHO (AAVHO) session and Manually Alternative VHO (MAVHO) session. Imperative session has high priority, e.g. if there are two VHO sessions at the same time, one due to Radio Signal Strength (RSS) going down (imperative) and the other due to user preferences change (alternative), the first request will be responded as high priority and the second request will be considered only if there is no any imperative VHO session under process, otherwise it has to wait in queue. In the AIVHO case, due to RSS going down the RATs list of priority based on user preferences will be provided by MU. When the first choice from the RATs list of priority could not be satisfied with Sufficient of Resources (SoRs) the Admission Control (AC) at destination PoS will automatically move to the next RAT in the list for satisfying the request and so on, once RAT of sufficient resources has been found, it will be checked by the destination PoS whether it is compliant to the rules and preferences of operators, if that is available, the session will be accepted, otherwise the request will be returned to the AC step to select the next RAT in list. Finally, the session will be rejected if there are no available resources for any RAT in the list. In the AAVHO case, the MU will select target RATs list of priority based on user preferences due to his/her profile change such as data rate, and take the same path of imperative request. In the MAVHO case, there is no need to RATs list of priority step because the RAT is selected manually by the user; therefore, the session would be rejected if SoRs are not available for user's selection session.

However, in the initiation phase, giving high priority for imperative sessions over alternative sessions may probably cause VHO connection failure in the alternative sessions as a result of waiting process in queue. Therefore, this paper proposes an improvement in the initiation phase for the traditional I AM 4 VHO algorithm by making a balance between the sessions. This in turn means that the imperative and alternative sessions will obtain the same priority of execution (50%). Each of the sessions is allowed to utilize unused portion of the other session when its own portion is fully used, otherwise they have to wait in queue. This is shown in Fig.1.

V. Numerical Analysis For The Improved I am 4 Vho Algorithm (Initiation Phase)

This analysis considers the situation in which there are two main types of VHO can be identified without background traffic: imperative and alternative. Alternative session and imperative session are referred to (Alt_{VHO}) and (Imp_{VHO}), respectively.

Let $Z = \{z_1 z_2, . . . ,z_i\}$ and $Y = \{y_1, y_2, . . . ,y_j\}$ be the sets of Imp_{VHO} and Alt_{VHO} sessions, respectively. Note that $i > 1$ and $j > 1$.

If the Imp_{VHO} has high priority over the Alt_{VHO} as the traditional I AM 4 VHO algorithm works, the probability of minimizing VHO connection failure (p_2) is computed as follows:

A. Imperative

$p_2(z_{Imp}) = p(z_i)$, z_{Imp} is only Imp_{VHO} sessions selected (1)

Where p is the probability of available Imp_{VHO} for any individual session.

B. Alternative

$$p_2(r_m \geq 1) = 1 - p_1(r_1 < 1),\ 1 - p_1(r_2 < 1), \ldots, 1 - p_1(r_m < 1) \quad (2)$$

Where:

$$p_1(r_m) = \binom{k}{r_m} p^{r_m} q^{k-r_m} = \frac{k!}{(k-r_m)!\,r_m!} p^{r_m} q^{k-r_m} \quad (3)$$

Where p_1 is the probability of available Alt_{VHO} for available sessions, k is the number of available sessions, r is the number of available successful sessions for

Alt_{VHO}, p is the probability of available Alt_{VHO} for any individual session and q is the probability of unavailable Alt_{VHO} for any individual session.

If the Alt_{VHO} and Imp_{VHO} have the same priority, the probability of minimizing VHO connection failure (p_2) is computed as follows:

$$p_2(z_{Imp}) = p(z_i),\ z_{Imp} \text{ is only } Imp_{VHO} \text{ sessions selected} \quad (1)$$

$$p_2(y_{Alt}) = p(y_j),\ y_{Alt} \text{ is only } Alt_{VHO} \text{ sessions selected} \quad (4)$$

To investigate probability of minimizing VHO connection failure thoroughly, set of variables of p for Alt_{VHO} (0.1, 0.5, 0.9) are assumed as shown in Fig.2, Fig.3 and Fig.4, respectively. These figures illustrate the probability of minimizing VHO connection failure (p_2) for the traditional I AM 4 VHO algorithm. It is improved for Alt_{VHO} as a result of increasing number of sessions with a minimum and maximum p_2 of (10%) and (99%) respectively. While the p_2 for Imp_{VHO} sessions score (100%), this is because they are given high priority over alternative sessions.

From Fig.5, it can be seen that the p_2 for Imp_{VHO} and Alt_{VHO} score (100%) due to the same priority of execution is given for both of them.

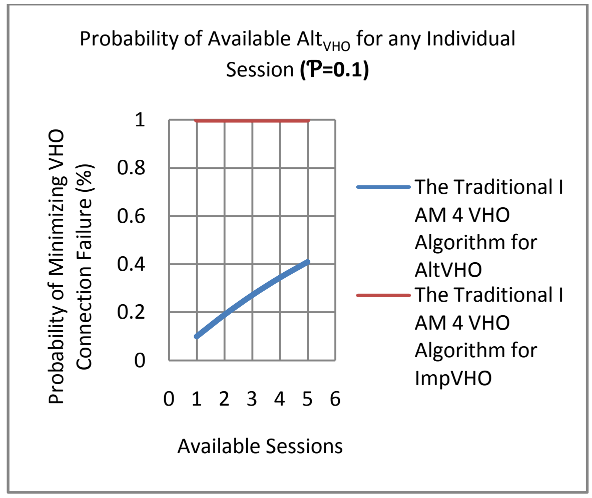

Fig.2. Comparison of Probability of Minimizing Vertical Handover (VHO) Connection Failure Sessions (p = 0.1) with High Priority of Execution for Imperative Sessions over Alternative Sessions

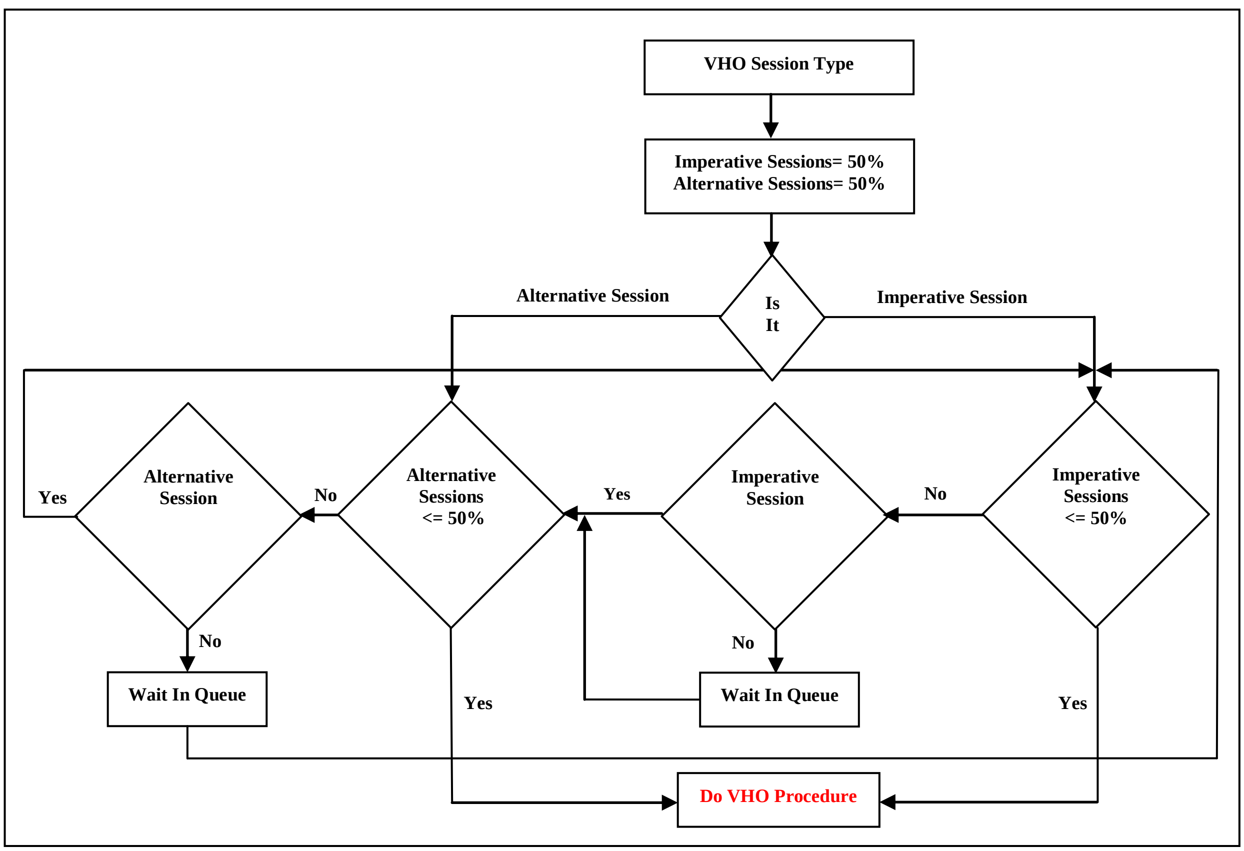

Fig. 1. The Improved Imperative Alternative MIH for Vertical Handover (I AM 4 VHO) Algorithm

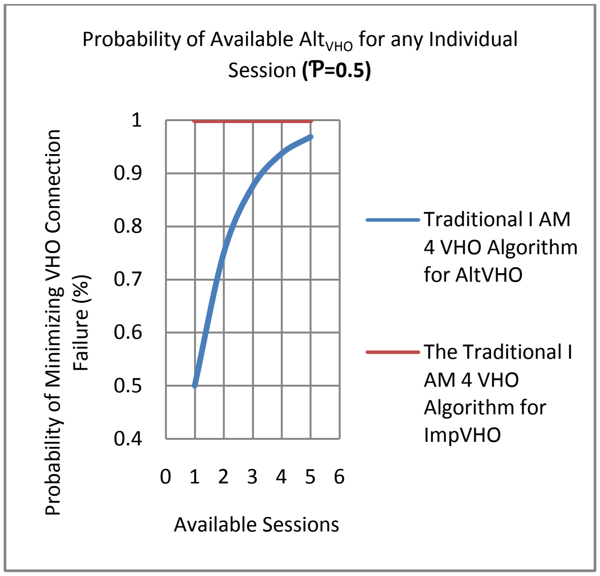

Fig.3. Comparison of Probability of Minimizing Vertical Handover (VHO) Connection Failure Sessions (p = 0.5) with High Priority of Execution for Imperative Sessions over Alternative Sessions

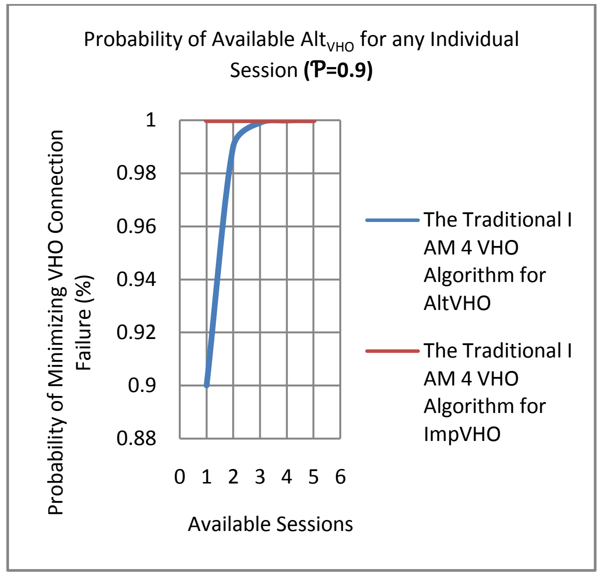

Fig.4. Comparison of Probability of Minimizing Vertical Handover (VHO) Connection Failure Sessions (p = 0.9) with High Priority of Execution for Imperative Sessions over Alternative Sessions

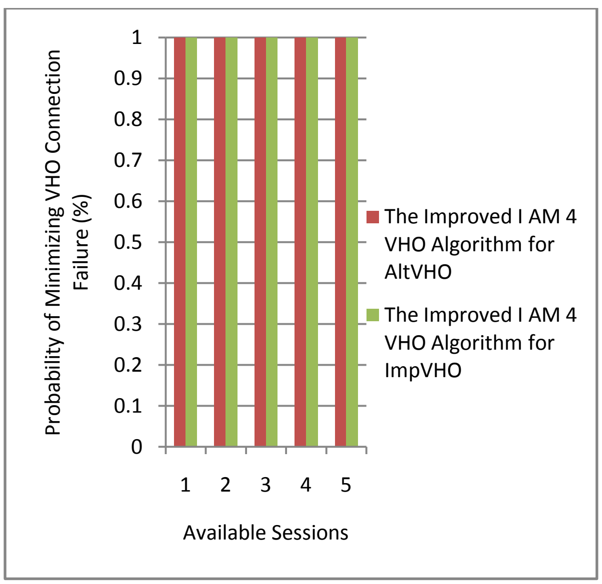

Fig.5. Comparison of Probability of Minimizing Vertical Handover (VHO) Connection Failure Sessions with the Same Priority of Execution between Imperative Sessions and Alternative Sessions

VI. CONCLUSION

This paper has presented an improvement on the traditional I AM 4 VHO algorithm for enhancing VHO in heterogeneous wireless networks environment. The numerical analysis of the improved I AM 4 VHO algorithm has shown lower VHO connection failure compared to the traditional I AM 4 VHO algorithm. In the future work, it would be preferable to simulate the improved I AM 4 VHO and evaluate the system performance.

REFERENCES

[1] Our vision: Committed to connecting the world. (2015). International Telecommunication Union (ITU). Retrieved 25 Oct, 2015, 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 Jul 2011.

[3] A. Haji, A. Ben Letaifa, and S. Tabbane, "Integration of WLAN, UMTS and WiMAX in 4G," 16th IEEE International Conference Electronics, Circuits, and Systems (ICECS), pp.307-310, 13-16 Dec 2009.

[4] N. Akkari, and S. Tohme, "Introducing Intelligent Vertical Handover in Next Generation Networks," IEEE International Conference Signal Processing and Communications (ICSPC), pp.728-731, 24-27 Nov 2007.

[5] Y. Nkansah-Gyekye, and J.I. Agbinya, "A Vertical Handoff Decision Algorithm for Next Generation Wireless Networks," 3rd International Conference on Broadband Communications, Information Technology & Biomedical Applications, pp.358-364, 23-26 Nov 2008.

[6] S. Benoubira, M. Frikha, and S. Tabbane, "Hierarchical Mobile IPv6 Based Architecture for Heterogeneous Wireless Networks Interworking," IEEE 3rd International Conference on Communication Software and Networks (ICCSN), pp.422-426, 27-29 May 2011.

[7] 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 2011 (WCNC 2011), pp.617-622, 28-31Mar 2011.

[8] 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 Oct 2010.

[9] M. Kassar, B. Kervella, and G. Pujolle, "An Overview of Vertical Handover Decision Strategies in Heterogeneous Wireless Networks," Computer Communications, vol.31, no.10, pp.2607-2620, 25 Jun 2008.

[10] E. Stevens-Navarro, and V.W.S. Wong, "Comparison between Vertical Handoff Decision Algorithms for Heterogeneous Wireless Networks," IEEE 63rd Vehicular Technology Conference(VTC), vol.2, pp.947-951, 7-10 May 2006.

[11] P.M.L. Chan, R.E. Sheriff, Y.F. Hu, P. Conforto, and C. Tocci, "Mobility Management Incorporating Fuzzy Logic for Heterogeneous a IP Environment," IEEE Communications Magazine, vol.39, no.12, pp.42-51, Dec 2001.

[12] W.T. Chen, J.C. Liu, and H.K. Huang, "An Adaptive Scheme for Vertical Handoff in Wireless Overlay Networks," 10th International Conference on Parallel and Distributed Systems (ICPADS), pp.541- 548, 7-9 Jul 2004.

[13] J. Mcair, and F. Zhu, "Vertical Handoffs in Fourth-Generation Multinetwork Environments," IEEE Wireless Communications, vol.11, no.3, pp.8-15, Jun 2004.

[14] Y. Gyekye-Nkansah, and J. Agbinya, "Vertical Handoffs Decision Algorithms Using Fuzzy Logic," International Conference on Wireless Broadband and Ultra Wideband Communications, pp.1-5, 2006.

[15] D. Sourav, R. Amitava, and B. Rabindranath, "Design and Simulation of Vertical Handover Algorithim for Vehicular Communication," International Journal of Engineering Science and Technology, vol.2, no.10, pp.5509-5525, 2010.

[16] P. Neves, J. Soares, and S. Sargento, "Media Independent Handovers: LAN, MAN and WAN Scenarios," IEEE GLOBECOM Workshops, pp.1-6, 30 Nov 2009–4 Dec 2009.

[17] G. Lampropoulos, A.K. Salkintzis, and N. Passas, "MediaIndependent Handover for Seamless Service Provision in Heterogeneous Networks," IEEE Communication Magazine, vol.46, no.1, pp.64-71, Jan 2008.

[18] IEEE P802.21/D10.0, "Draft Standard for Local and Metropolitan Area Networks: Media Independent Handover Services," Apr 2008.

[19] A. Pontes, D. Dos Passos Silva, J. Jailton, O. Rodrigues, and K.L. Dias, "Handover Management in Integrated WLAN and Mobile WiMAX Networks," IEEE Wireless Communications, vol.15, no.5, pp.86-95, Oct 2008.

[20] D. Corujo, C. Guimaraes, B. Santos, and R.L. Aguiar, "Using an Open-Source IEEE 802.21 Implementation for Network-Based Localized Mobility Management," IEEE Communications Magazine, vol.49, no.9, pp.114-123, Sept 2011.

[21] IEEE Standard for Local and Metropolitan Area Networks– Media Independent Handover Services, IEEE 802.21, Jan 2009.

[22] M. Kassab, J.M. Bonnin, and A. Belghith, "Technology Integration Framework for Fast and Low Cost Handovers-Case Study:WiFi –WiMAX Network," Journal of Computer Systems, Networks, and Communications, vol.2010, no.9, pp.1-21, Jan 2010.

[23] P. Vetrivelan, and P. Narayanasamy, "SMIRT with Call Admission Control (CAC) Based Vertical Handover Decision for Seamless Mobility in Multi-Access 4G Heterogeneous Wireless Overlay Networks," International MultiConference of Engineers and Computer Scientists (IMECS 2012), vol.1, pp.345, 14-16 Mar 2012.

[24] M. Tauil, A. Dutta, Y.H. Cheng, S. Das, D. Baker, M. Yajnik, D. Famolari, Y. Ohba, V. Fajardo, K. Taniuchi, and H. Schulzrinne, "Realization of IEEE 802.21 services and preauthentication framework," TridentCom 5th International Conference on Testbeds and Research Infrastructures for the Development of Networks & Communities and Workshops, pp.1-10, 6-8 Apr 2009.

[25] IEEE 802.21 Tutorial. (2006).IEEE 802.21. Retrieved 25 Oct, 2015, from http://www.ieee802.org/21/.

[26] S. Frei, W. Fuhrmann, A. Rinkel, and B.V. Ghita, "Improvements to Inter System Handover in the EPC Environment," 4th IFIP International Conferenceon on New Technologies, Mobility and Security (NTMS), pp.1-5, 7-10 Feb 2011.

[27] Y. Xiaohuan, Y. Ahmet Şekercioğlu, and N. Sathya, "A Survey of Vertical Handover Decision Algorithms in Fourth Generation Heterogeneous Wireless Networks," Computer Networks, vol.54, no.11, pp.1848-1863, 2 Aug 2010.

[28] S.S. Sengar, N. Tyagi, and A.P. Singh, "A Survey on WiMAX-3G Interworking," IEEE 3rd International Conference on Communication Software and Networks (ICCSN), pp.54-58, 27-29 May 2011.

[29] M. Lin, and R. Lanlan, "An End-to-End QoS Frame in Multimedia Provision for Tight-Coupled Interworking of IMS and WiMAX," IEEE International Conference on Networking, Sensing and Control (ICNSC) , pp.1153-1157, 6-8 Apr 2008.

[30] X. Fangmin, Z. Luyong, and Z. Zheng, "Interworking of Wimax and 3GPP networks based on IMS [IP Multimedia Systems (IMS) Infrastructure and Services]," IEEE Communications Magazine, vol.45, no.3, pp.144-150, Mar 2007.

[31] B. Bakmaz, Z. Bojkovic, and M. Bakmaz, "Internet Protocol Multimedia Subsystem for Mobile Services," 14th International Workshop on Systems, Signals and Image Processing and 6th EURASIP Conference Focused on Speech and Image Processing, Multimedia Communications and Services, pp.339-342, 27-30 Jun 2007.

[32] L. Youngsuk, K. Namhi, K. Seokkap, and K. Younghan, "An Efficient QoS Control Mechanism for IMS Based Convergence Network," 2nd IEEE/IFIP International Workshop on Broadband Convergence Networks (BcN '07), pp.1-12, 21-21 May 2007.

[33] M.A. Qadeer, A.H. Khan, J.A. Ansari, and S. Waheed, "IMS Network Architecture," International Conference on Future Computer and Communication (ICFCC), pp.329-333, 3-5 Apr 2009.

[34] 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, Jun 2013.

[35] O. Khattab, and O. Alani, "A Survey on MIH vs. ANDSF: Who Will Lead the Seamless Vertical Handover throygh Heterogeneous Networks," International Journal of Future Generation Communication and Networking, vol.6, no.4, pp.1-11, Aug 2013.

[36] O. Khattab, and O. Alani, "Algorithm for Seamless Vertical Handover in Heterogeneous Mobile Networks," IEEE Science and Information Conference (SAI 2014), pp 1-8, 27-29 Aug 2014.

[37] A. Ahmed, L. Boulahia, and D. Gaiti, "Enabling Vertical Handover Decisions in Heterogeneous Wireless Networks: A State-of-the-Art and A Classification," IEEE Communications Surveys & Tutorials, vol.PP, no.99, pp.1-36, 2013.

[38] K. Pahlavan, P. Krishnamurthy, A. Hatami, M. Ylianttila, J. Makela, R. Pichna, and J. Vallstron, "Handoff in Hybrid Mobile

Data Networks," IEEE Personal Communcation, vol.7, no.2, pp.34–47, Apr 2000.

[39] M. Ylianttila, J. M¨akel¨a, and K. Pahlavan, "Analysis of Handoff in a Location-Aware Vertical Multi-Access Network," Computer Network, vol.47, no.2, pp.185–201, Feb 2005.

[40] M. Emmelmann, T. Langg¨aertner, and M. Sonnemann, "System Design and Implementation of Seamless Handover Support Enabling Real-Time Telemetryhighly Mobile Users," 6th ACM Iinternational Symposium on Mobility Management and Wireless Access, pp.1–8, 2008.

[41] A. Haider, I. Gondal, and J. Kamruzzaman, "Dynamic Dwell Timer for Hybrid Vertical Handover in 4G Coupled Networks," 73rd Vehicular Technology Conference (VTC Spring), pp.1–5, 2011.

[42] N. Saxena, and A. Roy, "Novel Framework for Proactive Handover with Seamless Multimedia over WLANS," IET Communications, vol.5, no.9, pp.1204–1212, Jun 2011.

[43] D. Li, E. Van Lil, and A. Van de Capelle, "Improving Slow-Start Based Probing Mechanisms for Flow Adaptation after Handovers," Computer Network, vol.56, no.1, pp.329–344, Jan 2012.

[44] S. Mohanty, and I. Akyildiz, "A cross-Layer (layer 2+3) Handoff Management Protocol for Next-Generation Wireless Systems," IEEE Transactions on Mobile Computing, vol.5, no.10, pp.1347-1360, Oct 2006.

[45] Z. Becvar, P. Mach, and B. Simak, "Improvement of Handover Prediction in Mobile WIMAX by Using Two Thresholds," Computer Network, vol.55, no.16, pp.3759–3773, Nov 2011.

AUTHOR

Dr. Omar Khattab received his PhD degree in Data Telecommunications and Networks at the School of Computing, Science and Engineering from Salford University, United Kingdom. He was awarded the Dean's Prize for the best postgraduate student in recognition of his outstanding research works and achievements as a postgraduate research student. He has more than ten years of teaching experience in Computer Networks and Information Technology. He obtained a lot of professional Certificates in the field Computer Networks. He published in many research publications as well as participated in specialized Conferences. His research interests include Heterogeneous Wireless Networks, Mobile Networks, Mobility Management, Wireless Communication and Computer Networks.