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Performance Analysis of Reducing Signaling Cost for a Roaming User in Vertical Handover Algorithm for Mobile Networks

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Abstract: *Ubiquitous networks allow the coexistence of different wireless technologies such as GSM (Global System for Mobile Communication), Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX), Universal Mobile Telecommunications System (UMTS) and Long Term Evolution (LTE). Where one of the challenging issues in Next Generation Wireless Systems (NGWSs) is achieving seamless Vertical Handover (VHO) during Mobile User (MU) mobility between these technologies. This paper presents a performance evaluation on the existing 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 algorithm shows that the VHO signaling cost is extremely reduced.*

Keywords: *Heterogeneous Wireless Networks, Signaling Cost, Vertical Handover (VHO)*

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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. 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 systems 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 Mobile Users (MUs) with roaming capability across different networks. One of the challenging issues in Next Generation Wireless Systems (NGWSs) 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 of the ongoing sessions. This paper presents a performance evaluation on the Imperative Alternative MIH for Vertical Handover (I AM 4 VHO) algorithm for enhancing VHO in heterogeneous wireless networks environment. 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 algorithm is presented. In section V, numerical analysis of the algorithm is presented and finally, the conclusion is included in section VI.

II. Vertical Handover Management

The The process 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 most of the research papers have been divided VHO management into three phases; Collecting Information, Decision and Execution [3, 4, 5, 6, 7 and 8] 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, resources of old the RAT is eventually released.

III. Related Work

There are three main Access Network Selection (ANS) methods used in VHO which have been overviewed in [9]: Multiple Attribute Decision Making (MADM), Fuzzy Logic (FL) and Neural Networks (NNs). It has been concluded in [9], that the majority VHO approaches in the literature were based on the MADM and FL compared to the NNs. The handover seamlessness generally means lower packet loss, minimal handover latency, lower signaling overheads and limited handover failures [10]. In [11], many of VHO approaches have been surveyed where it has been concluded that the VHO approaches have only concentrated on the packet loss and the latency. Whereas the connection failure and the signaling cost are the other two vital factors in providing seamless VHO have been considered in [12, 13 and 14]. However, in [12, 13 and 14] no evaluation or validation has been provided for signaling cost.

IV. The Algorithm

In [12 and 13], the IAM 4 VHO algorithm has been presented in order to achieve low VHO connection failure and low signaling cost. The algorithm defines 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 will have 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 Point of Service (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.

The algorithm has used a Mamdani Fuzzy logic Inference (FIS) for computing Handover Factor (HF) which determines whether VHO is required or not i.e. If (HF > 0.5), then initiate handover; otherwise reject session [12]. Results of the algorithm have showed low VHO connection failure whereas the signaling cost could be reduced as result of avoiding unnecessary VHO processes. However, in [12 and 13], no evaluation or validation has been provided for signaling cost.

V. Numerical Analysis

In this section, a numerical analysis for signaling cost is presented in order to evaluate the performance of the algorithm during the VHO. There are three periods of time latency in the algorithm associated with the three VHO types: Automatically Imperative VHO (AIVHO) session due to RSS going down, Automatically Alternative VHO (AAVHO) session due to user's profile change and Manually Alternative VHO (MAVHO) session due to RAT is selected manually by the user, I refer them to the figure, table and text TAI, TAA and TMA, respectively. In this analysis, three VHO scenarios between Wi-Fi and WiMAX are considered. This is shown in Figure 1 and notations in Table 1.

5. 1 Scenarios

Scenario 1 (Imperative VHO): Automatic

The MU starts moving out of the coverage of WiFi due to faded RSS; therefore, the handover may take place to available WiMAX network to keep the session going.

Scenario 2 (Alternative VHO): Automatic

As the MU starts moving into WiMAX network, it could automatically change its connection from WiFi to WiMAX to keep the session depending on the user profile.

Scenario 3 (Alternative VHO): Manual

As the MU starts moving into WiMAX network, it could manually change its connection from WiFi to WiMAX to keep the session depending on the user selection.

5.2 Discussions

To compute the VHO signaling cost for the algorithm, I assume that the recorded HF for all scenarios is (HF $\leq$ 0.5) as result of avoiding unnecessary VHO processes. Fig2, Fig3 and Fig4 illustrate the VHO signaling cost of 19, 20 and 14 for TAI, TAA and TMA respectively. From these figures it can be seen that the VHO signaling cost for the algorithm is extremely improved compared with the system without algorithm due to reducing the time sequence for VHO signaling cost.

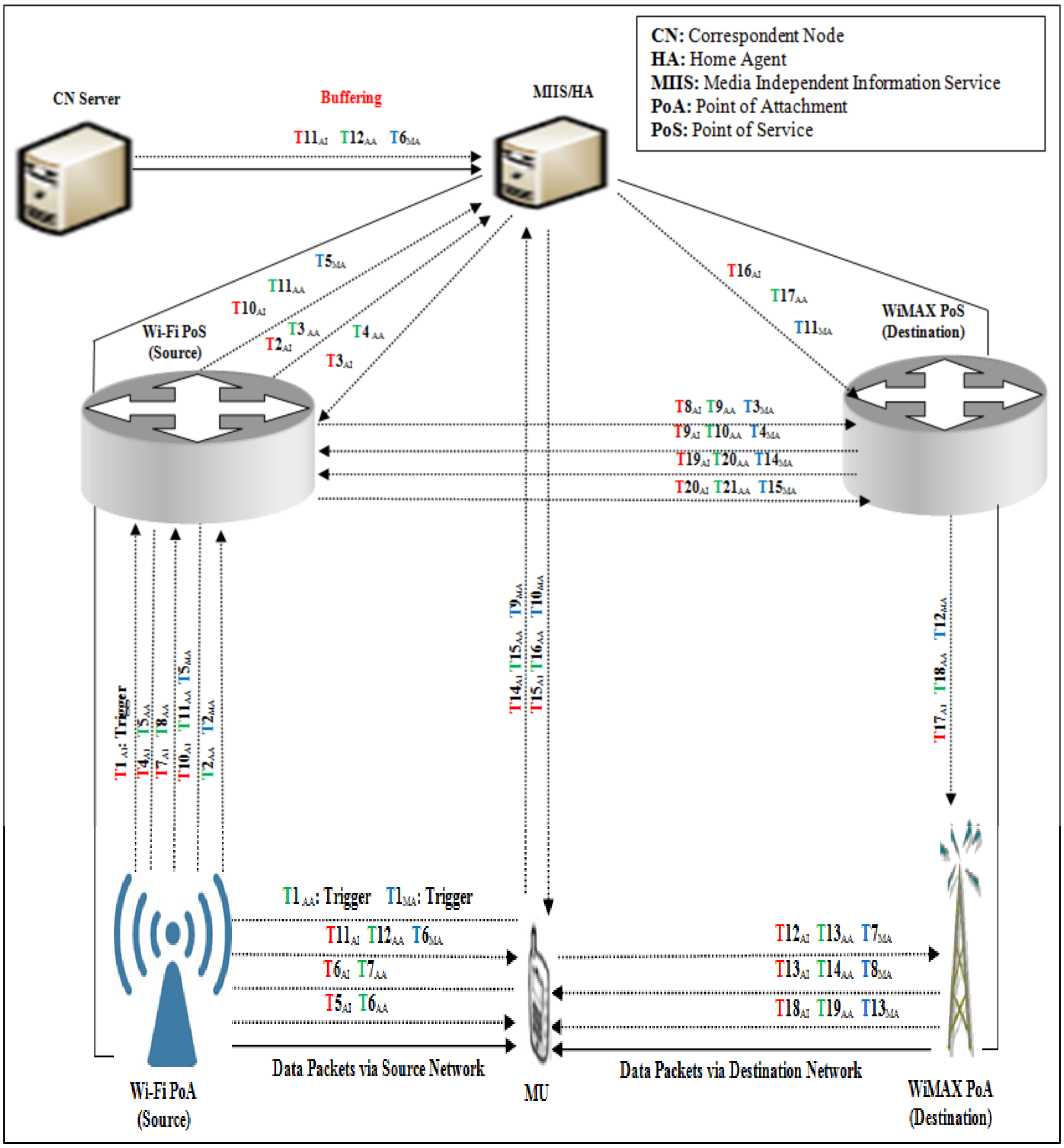

Figure 1. Time sequence for VHO signaling cost of the algorithm

Table 1. Notations on time sequence for VHO signaling cost of the algorithm

Time Sequence			VHO Signaling Sequence			Event
T_{AI} Scenario 1	T_{AA} Scenario 2	T_{MA} Scenario 3				
1	1	1	$T1_{AI}$			Automatically Imperative VHO (AIVHO) triggering.
				$T1_{AA}$		Automatically Alternative VHO (AAVHO) triggering.
					$T1_{MA}$	Manually Alternative VHO (MAVHO) triggering.
IF HF > 0.5, Then Initiate Handover and Compute Time Sequence for VHO Signaling Cost; Otherwise Reject Session						
	2	2		$T2_{AA}$	$T2_{MA}$	AAVHO/MAVHO triggering pass to Wi-Fi PoA.
2	3		$T2_{AI}$	$T3_{AA}$		MIIS available RATs request.
3	4		$T3_{AI}$	$T4_{AA}$		MIIS available RATs response.
4	5		$T4_{AI}$	$T5_{AA}$		Pass RATs to Wi-Fi PoA.
5	6		$T5_{AI}$	$T6_{AA}$		Pass RATs to MU.
6	7		$T6_{AI}$	$T7_{AA}$		Pass RATs list of priority to Wi-Fi PoA.
7	8		$T7_{AI}$	$T8_{AA}$		Pass RATs list of priority to Wi-Fi PoS.
8	9	3	$T8_{AI}$	$T9_{AA}$	$T3_{MA}$	Pass RATs list of priority or RAT based on user selection to WiMAX PoS.
9	10	4	$T9_{AI}$	$T10_{AA}$	$T4_{MA}$	Pass target RAT to Wi-Fi PoS.
10	11	5	$T10_{AI}$	$T11_{AA}$	$T5_{MA}$	Notify MIIS server to start early buffering for new data packets which are sent by server and pass target RAT to Wi-Fi PoA concurrently.
11	12	6	$T11_{AI}$	$T12_{AA}$	$T6_{MA}$	Start buffering and pass target RAT to MU.
12	13	7	$T12_{AI}$	$T13_{AA}$	$T7_{MA}$	Authentication request with WiMAX PoA.
13	14	8	$T13_{AI}$	$T14_{AA}$	$T8_{MA}$	Authentication response from WiMAX PoA.
14	15	9	$T14_{AI}$	$T15_{AA}$	$T9_{MA}$	Binding request with HA.
15	16	10	$T15_{AI}$	$T16_{AA}$	$T10_{MA}$	Binding response from HA.
16	17	11	$T16_{AI}$	$T17_{AA}$	$T11_{MA}$	Release new data packets (buffering) to WiMAX PoS.
17	18	12	$T17_{AI}$	$T18_{AA}$	$T12_{MA}$	Pass new data packets to WiMAX PoA.
18	19	13	$T18_{AI}$	$T19_{AA}$	$T13_{MA}$	Pass new data packets to MU.
19	20	14	$T19_{AI}$	$T20_{AA}$	$T14_{MA}$	Release request with Wi-Fi PoS.
20	21	15	$T20_{AI}$	$T21_{AA}$	$T15_{MA}$	Release response from Wi-Fi PoA.
19	**20**	**14**	**Time Sequence for VHO Signaling Cost**			

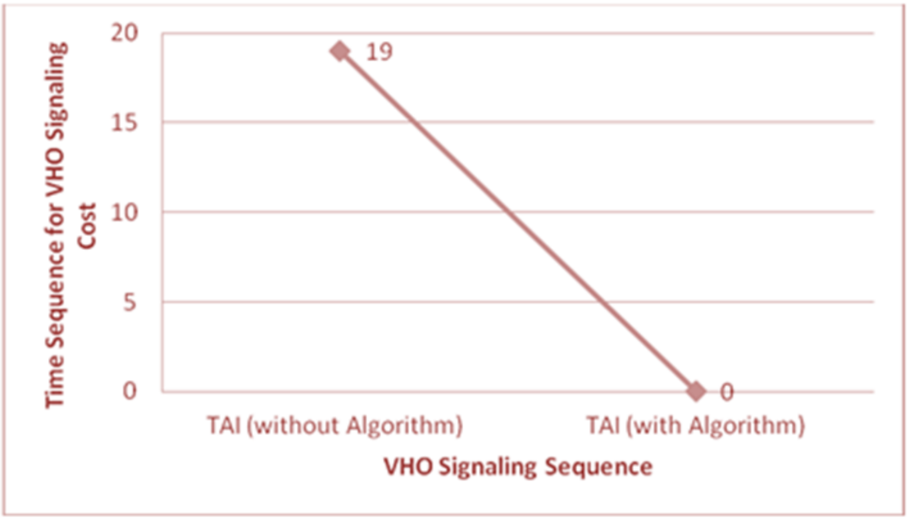

Figure 2. Comparison of VHO signaling cost for automatically imperative VHO

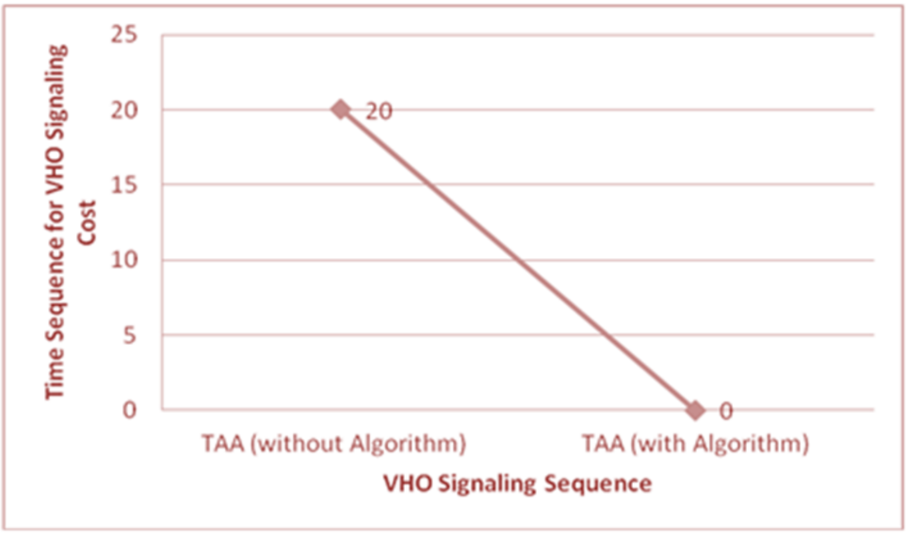

Figure 3. Comparison of VHO signaling cost for automatically alternative VHO

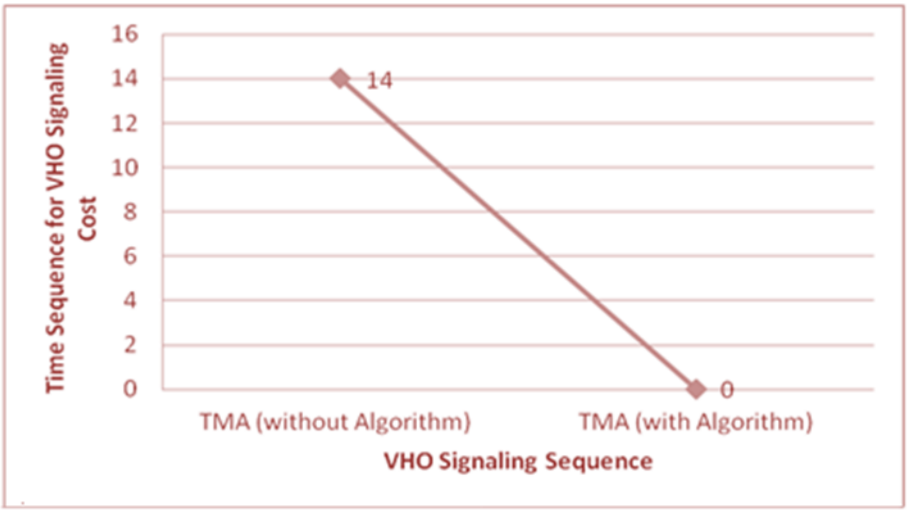

Figure 4. Comparison of VHO signaling cost for manually alternative VHO

VI. Conclusion

This paper has presented the performance evaluation on the I AM 4 VHO algorithm for enhancing VHO in heterogeneous wireless networks environment. The numerical analysis of the algorithm has showed that the VHO signaling cost is extremely reduced compared with the system without algorithm. In the future work, it would be preferable to simulate the algorithm and evaluate the system performance.

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