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Research paper



Performance Evaluation of the Vertical Handover in the Wireless Networks

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Abstract

In mobile communication, Vertical handover is a process when a mobile switches from one network to another without any interruption. This paper gives three different proposed types of interworking architectures were designed between WLAN, UMTS and WiMAX networks based on the quality of service (QoS). Performance and evaluation of handover based on various parameters like handover delay, received power, signal to noise ratio, throughput, Traffic sent and traffic received is done and the performance of the interworking architecture is analyzed from the simulation results using OPNET Modeller 14.5.

Keywords: *Vertical handover; WLAN; WIMAX; UMTS; QoS; Heterogeneous networks; OPNET modeler.*

1. Introduction

Heterogeneous wireless networks such as WLAN, UMTS and WiMAX require efficient handover mechanisms to guarantee seamless connectivity [6, 24]. Traditionally the handover process was only within the cells of the same network. However, due to the growing number of networks and wireless access technologies, there was a need to transfer the call between cells of different networks [7]. Handover is classified as horizontal and vertical handovers, depending upon whether the connection is transferred within the network or to a different network.

– Horizontal handover: [1, 2] When a connection is handed over to the base station within the same network, it is called a horizontal handover or intra-system handover. Since both involved base station shares the radio resources, network interface and QoS parameters, it is relatively easy to make a horizontal handover.

– Vertical handover: When the connection is handed over to the base station of a different network, it is called a vertical handover or inter-system handover [3]. The connection is transferred to a different radio access network, e.g. handover between UMTS and WiMAX [4]. During vertical handover, the IP address of the connection is changed. [6, 7] It requires the mapping of QoS parameter as both networks have a different QoS model [16]. In order to analyze the performance of handover vertical on a heterogeneous network, we focus and analyze the following parameters: Received power (w), signal to noise ratio (dB), throughput (bits/sec), traffic sent and traffic received. With the simulation results, we will determine the performance of handover vertical in the wireless network and discover the factors which can affect the performance.

We evaluated performance such as packet loss, delay and throughput of WLAN, UMTS and WiMAX during handover [4].

We used OPNET in our simulation for a different reason [8, 10]:

- The basic concept of simulation is easy to comprehend through analytical methods.
- We can run the Opnet model on various several sets of parameter values to determine the performance measures in each of the cases.

Our contribution in this work is the evaluation of the performance of handover vertical in the proposed interworking architectures between WLAN, UMTS and WiMAX based on several metrics in order to maintain the connectivity. The rest of this paper is structured as follows. In Section 2, we briefly describe the handover process. In Section 3, we will review some related work. The proposed interworking architecture and the performance analysis are presents in Section 4. The conclusion and the future work are given in the last section.

2. Handover Process

In this section, we have described the handover process as shown in Fig. 1 [14].

- Handover Initiation: The handover process can be initiated by the mobile terminal or the network [17]. In case of the mobile terminal initiated handover, the mobile terminal takes the decision of the handover. In case of the network initiated handover, the mobile terminal periodically sends the report of the connection status to the controller and based on the report the controller decides if the handover needs to be performed.

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[14].The criteria for handover depend on the handover scheme which is used in the network. It can be based on QoS, Received Signal Strength (RSS) or Signal to Noise Ratio (SNR).

- Network Discovery: When the network or a mobile terminal initiates the handover, a network discovery mechanism is required to determine the available base stations for handover. The mobile terminal scans for the nearby base stations during the network discovery mechanism [19].

- Network Selection: The network controller has to select one base station to handover after identifying the available base stations and the selection is done when a new base station has higher RSS than the current base station [16].

- Handover decision: The handover decision is based on criteria and there should be base stations available which can support the current ongoing call [22].

- Authentication: Once the decision of the handover is made, and the new base station is selected for the handover, the new base station has to be verified for authentication and authorization [19, 22].

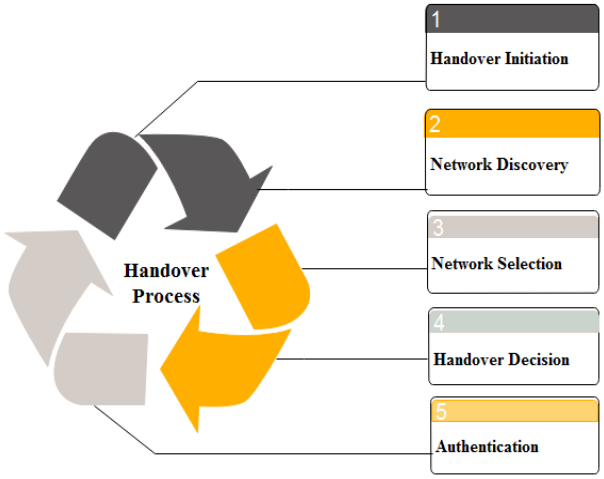

Fig. 2: Handover Process

3. Related Work

Most of the existing work was done to evaluate the performance of handover in heterogeneous networks. Khan et al. proposed an interworking architecture between WiMAX and UMTS to eliminate the packet loss due to handover and to maintain the connectivity of an ongoing call. Nguyen-Vuong and Agoulmine proposed an interworking architecture based on 3GPP standards and proposed a handover procedure which promises low interruption time and a low packet loss during the switching of the communication. Priyanka and Meenakshi have analyzed the performance of quality of services for an IEEE 802.16 based on WiMAX network. Edwin and Shaji studied a handover which considers the signal strength along with hysteresis and threshold, the estimation of dependence on mobile velocity and free capacity during the handover process. Reem et al., proposed a framework for interworking WLAN, Wi-MAX and LTE using IP Multimedia Subsystem (IMS) in order to provide real-time multimedia services and high quality during handover. Yuan et al. studied the performance improvement of SRVCC using OPNET network simulation software and proposed various optimization ideas to provide a better experience for users with seamless voice over LTE.

4. Simulation and performance analysis of vertical handover in Opnet Software

In the implementation of our different scenarios we have used the OPNET Modeler 14.5 [12, 13]. Our work consists in the design of the WLAN, WiMax and UMTS networks. The network also includes the mobile users whose movements were defined by way ourselves as it is illustrated in the following screenshots:

4.1. Proposed Interworking Architecture

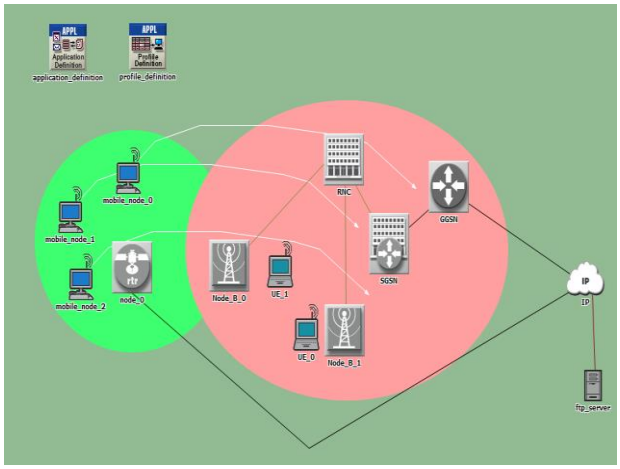

Fig. 2: Simulation topology of handover between WLAN and UMTS

This scenario is the implementation of vertical handover between WLAN and UMTS, we have three mobiles and their trajectory is from WLAN to UMTS.

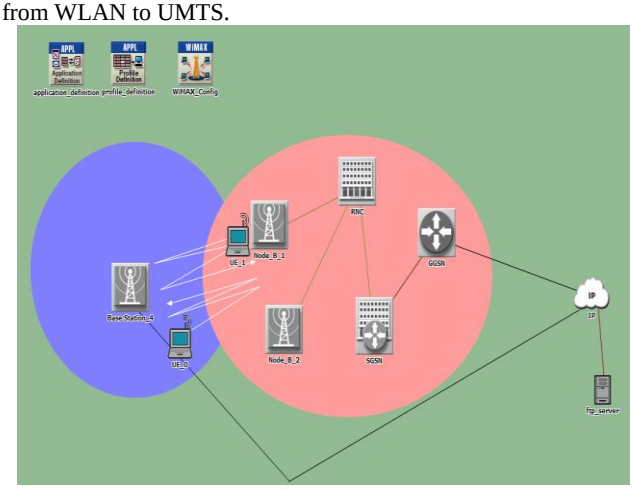

Fig. 3: Simulation topology of handover vertical between Wimax and UMTS

This scenario is the implementation of vertical handover between WiMax and UMTS, we have two users the first is from UMTS to WiMax and the second is from WiMax to UMTS.

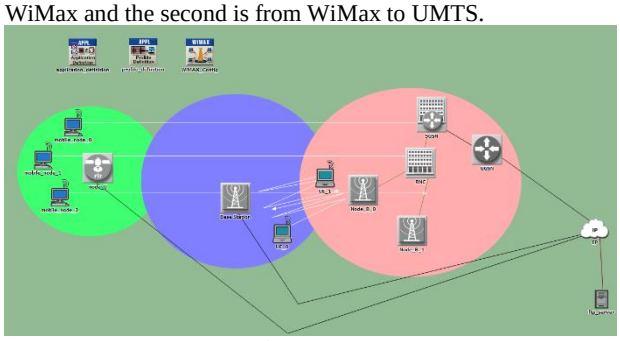

Fig. 4: Simulation topology of handover vertical between WLAN, WiMax and UMTS

This scenario is a combination of all three networks WLAN, Wi-MAX and UMTS, we have three mobiles and their trajectory is from WLAN to WiMax to UMTS.

4.2. Performance Analysis

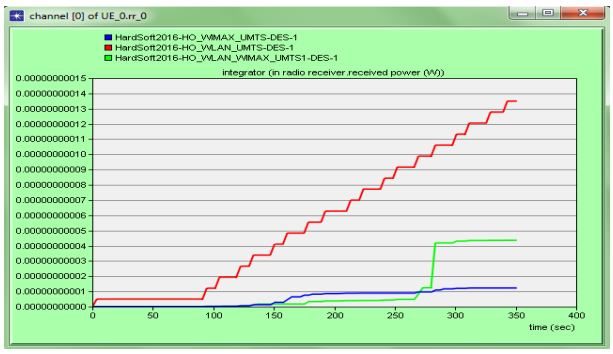

Fig. 5: Received Power

This figure shows the received power during vertical handover according the time in three scenarios, we can see that the maximum value in the WiMAX-UMTS interworking architecture is almost 1×10-11 W ie. -80 dBm, a peak of the WLAN-UMTS heterogeneous network equal 1.4×10-11 W ie -78.53dBm and a maximum value of the WLAN-WiMAX-UMTS heterogeneous network is almost 5×10-12 W ie. -83.01 dBm. It is clear from the results that the received power in the WLAN-UMTS interworking architecture is higher than WiMAX-UMTS and WLAN-WiMAX-UMTS.

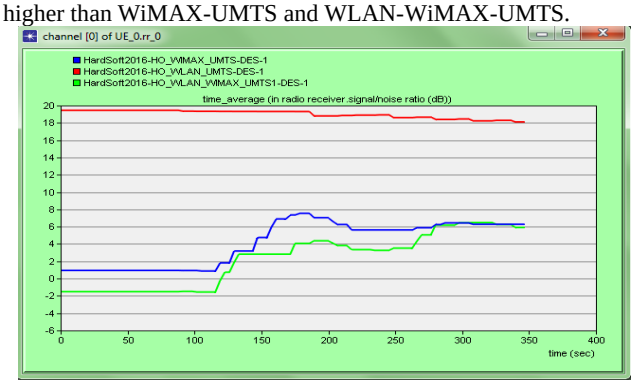

Fig. 6: Signal to noise radio

Figure 6 shows the SNR of the signal received by all the three interworking architectures. It was found that the signal to noise ratio in WLAN-UMTS interworking architecture is better since the no. of packets dropped is less.

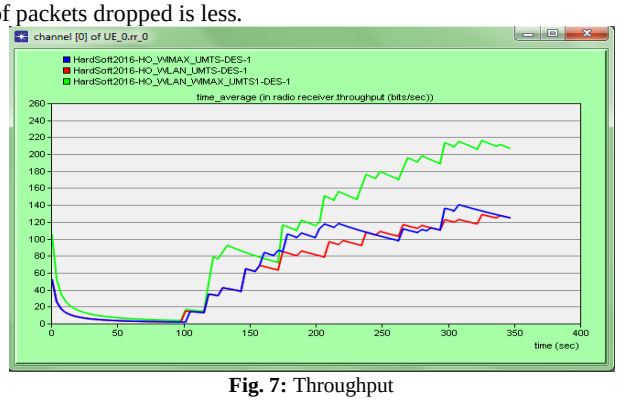

Fig. 7: Throughput

Based on the maximum throughput value in Figure 7, the maximum throughput in the proposed interworking architecture WiMAX-UMTS, WLAN-UMTS and WLAN-WiMAX-UMTS are 140 bits/sec, 130 bits/sec and 218 bits/sec, respectively. It is obvious that the handover between WLAN-WiMAX -UMTS can lead to larger maximum throughput. This is what we expected.

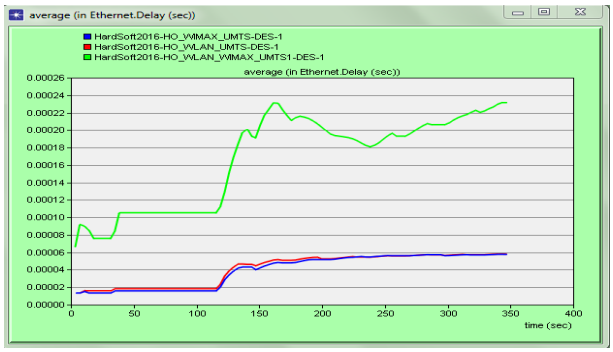

Fig. 8: Delay

Figure 8 shows the handover delay for video and voice services respectively. When the time taken to allocate bandwidth for the mobile node is null, the delay in WLAN-UMTS interworking architecture is lesser, it is obvious that the vertical handover between WLAN-WiMAX-UMTS networks has better performance than the vertical handover between WLAN-UMTS and WiMAX-UMTS networks

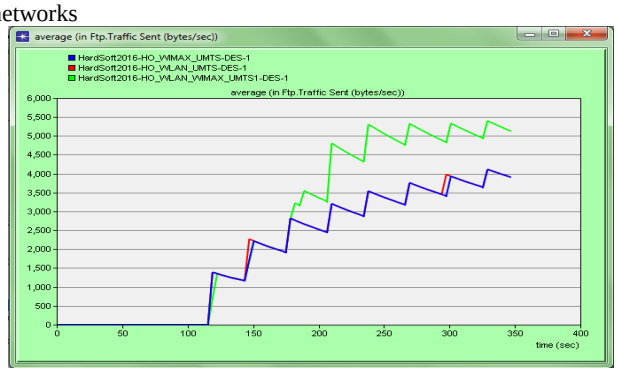

Fig. 9: Traffic Sent

Figure 9 represents the traffic received according the time, it's clear from the results that the traffic sent in WLAN-WiMAX-UMTS interworking architecture is higher than WiMAX-UMTS and WLAN-UMTS.

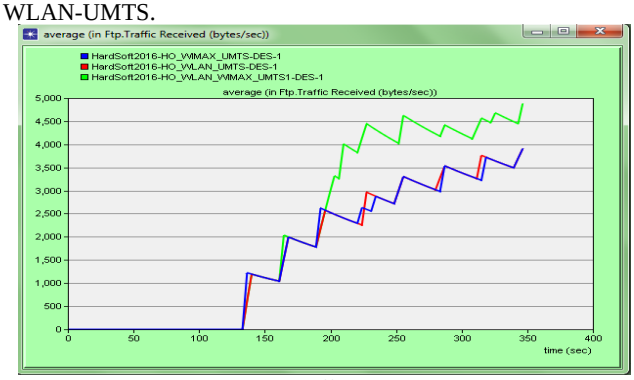

Fig. 10: Traffic Received

Figure 10 shows the traffic received according the time and it will be usually high for mobile which receives signal continuously and hence it is high for vertical handover in WLAN-WiMAX-UMTS interworking architecture.

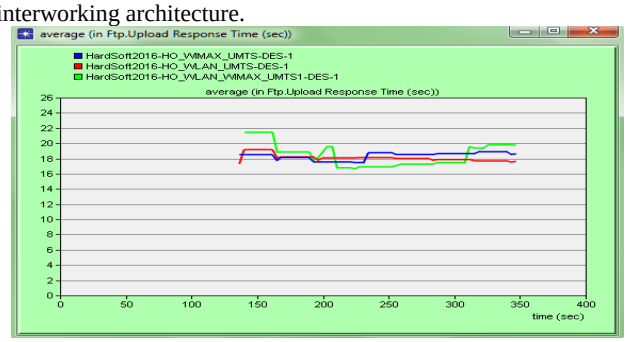

Fig. 11: Upload Response Time

Figure 11 represents the upload response time according the time; it's clear from the results that there is almost no difference between the upload response times of all interworking architectures.

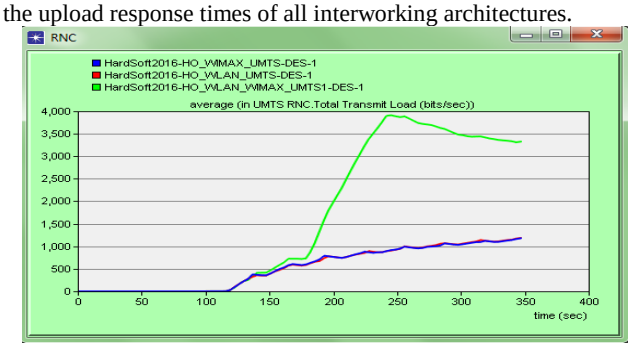

Fig. 12: Total Transmit Load

Figure 12 shows the total transmit load according the time, we can see that the total transmit load in WLAN-WiMAX-UMTS interworking architecture is higher than the total transmit load in WiMAX-UMTS and WLAN-UMTS interworking architecture.

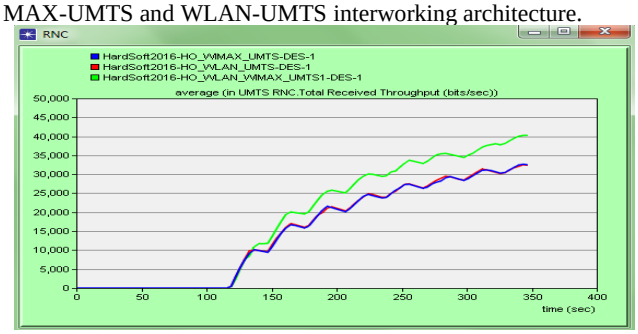

Fig. 13: Total Received Throughput

According to Figure 13, we can see that the total received throughput increase as moving left to right. Indeed, the peak average in WLAN-WiMAX-UMTS interworking architecture is almost 40,000 bits/sec and a maximum value in the WLAN-UMTS and WiMAX-UMTS interworking architectures are 30,000bits/sec.

5. Conclusion

In this paper, we have evaluated the effect of some parameters like received power, signal to noise ratio, throughput, delay, traffic sent and traffic received in the performance of vertical handover in three proposed interworking architectures (WLAN-WiMAX-UMTS, WLAN-UMTS and WiMAX-UMTS). Our simulation results show that the vertical handover schemes have better performances than the conventional handover schemes and it is obvious that the handover in WLAN-WiMAX-UMTS heterogeneous network has better performance than the handover in WLAN-UMTS and WiMAX-UMTS heterogeneous network. In future work, we will propose a framework with a generic model that takes into consideration the asses of the energy cost of different vertical handover (VH) schemes, however, studying the cost of the handover in term of energy.

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