International Journal of Engineering & Technology, 7 (4.29) (2018) 148-151

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper



Vertical Handover Evaluation for Heterogeneous Networks

Mohd Taha Ismail[1,2], Hassan Dao[1], Megat F. Zuhairi[1], Muhammad Azmin Mohamed Ghazali[1]

[1]Malaysian Institute Information Technology, Universiti Kuala Lumpur, MALAYSIA
[2]Universiti Kebangsaan Malaysia, Bandar Baru Bangi, Selangor, MALAYSIA

Abstract

This study is to simulate a handover in heterogeneous network using MATLAB. The simulation comprises of three different networks that overlap between each other and a UE will be moving across the networks. In mobile telecommunication, mobility management in heterogeneous networks will require a vertical handover in order to utilise different mobile technologies. To achieve a seamless handover between the systems, IEEE 802.21 is set to support algorithm enabling seamless handover in heterogeneous network. Handover failures and unnecessary handoff may be provoked in many situations which is causing a problem in seamless handoff. Thus, the algorithm is tested to minimize handover failures and unnecessary handoff. The controlled environment and a comprehensive analysis that covers the signal strength are evaluated.

Keywords: *Handoff, Heterogeneous network, Vertical Handover*

1. Introduction

Wireless technology has become the most demanded telecommunication technology these days. This is due the increasing number of mobile device users throughout the globe. Based on the data compiled by AF-Studio.pl and Super Monitoring in smartphone ownership, a very sudden increase in number of smartphone users between the years of 2011 to 2013, an increasing of 21% in number of smartphone users are recorded [1]. Furthermore, the increasing number of smartphone users is directly proportional to the demand of mobile telecommunication technology.

Moreover, in achieving the goals, LTE 3GPP has defined a framework to support mobility management and handover management [2]. Implying the idea of knowing the increase in number of users' equipment or mobile devices, handover in mobile telecommunication becomes the essence of mobility to the user. Thus, making the mobility management over heterogeneous wireless networks becomes an interesting area.

In mobile telecommunication, mobility management in heterogeneous network will require a vertical handover (VHO) which falls into the classification of horizontal and vertical handovers. Specifically, VHO is an inter-system handover that occurs between different network technologies as for example, an IEEE 802.11 access point and a 4G base station.

Heterogeneity in multi-network can be achieved if a suitable handoff metric is used. Although signal strength of the chief handoff metric is being used, it still cannot be utilized due to different physical techniques by each network [3]. An IEEE 802.21 is set to support algorithm enabling seamless handover in heterogeneous network. The study investigates vertical handover decision(VHD) algorithms. The result is analysed and evaluated in terms of the performance in handover handling to overcome handover failures and unnecessary handoff.

2. Related works

2.1. LTE Advance

LTE-A(LTE Advanced) or known as the LTE Release 10 was introduced with major new feature and specifications such as IMS-voice to support first priority voice call session for emergencies. LTE or the E-UTRAN (Evolved Universal Terrestial Access Network) is a standard for wireless communication of high-speed data for mobile phones. Although it was introduced as 4G wireless service, the 3GPP release 8 and 9 does not meet the technical requirements set forth by the ITU-R. The standard is developed by the 3GPP (3rd Generation Partnership Project), a group that responsible for standardizing and improving UMTS (International Telecommunication Union Radio Communication Sector) organization in its IMT Advanced specification which is LTE Advanced standard.

Table 1: Summary of Related Works

Research	Network	VHD method	Handover
Simple regressive differential prediction and decision (RDPD) using Markov decision algorithm	LTE-A, 3GPP	RSSI	Vertical
Critical review on VHD algorithm in different parameters.	Cellular Network and WLAN cell	HNE, HTS, HTE	Vertical
Smart triggering scheme was proposed based on Received Signal Strength	WMAN WLAN	HNE, HTS, HTE	Vertical

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Indication (RSSI)			

2.2. IEEE 802.16m WiMAX

IEEE 802.16 is a series of wireless broadband standards written by the Institute of Electrical and Electronics Engineers (IEEE). IEEE 802.16m or Wireless MAN- Advanced is a candidate for the 4G in the competition with the LTE Advanced standard. IEEE standard 802.16-2001 defines the Wireless MAN air interface specification for wireless metropolitan area networks (MANs). This standards act as a new tool in the effort to link homes and businesses for telecommunication networks worldwide. The wireless MAN offers an alternative to the existing cabled access networks.

2.3. IEEE 802.11 WLAN

A Wireless LAN or normally known as WLAN is one in which a multiple mobile user can be connected to a LAN using wireless radio connection. Referring to the IEEE, the standard of 802.11 is set of media access control (MAC) and physical layer (PHY) specifications for implementing the wireless local area network or WLAN. In WLAN, a Wi-Fi term is used which actually use the specifications in the 802.11 family**.**

2.4. Vertical Handover

Handover or handoff (HO) is a telecommunication term that is wide-known process in a connected cellular or data session transfer from one cell site to another without disconnecting the session. Cellular services offer mobility function to the user in which, allowing user to move in a cell site range or to be handover to other cell sites for better performance. As mobility is essential to the mobile cellular communication, it offers benefits to the end users such as low delay services, voice or real time video connections in a high speed moving. Although mobility in high speed is a challenge to the telecommunication bodies, LTE promises more than former technologies to overcome this challenge.
In telecommunication, there are two classification of handover depending on the network involved in the handover process which is horizontal handover (HHO) and vertical handover (VHO). In heterogeneous network, where inter-system with different mobile technologies is applied as for example, an IEEE 802.16m base station (BS) and 4G LTE BS, VHO is occurred. Fig. 1 shows the difference between HHO and VHO.

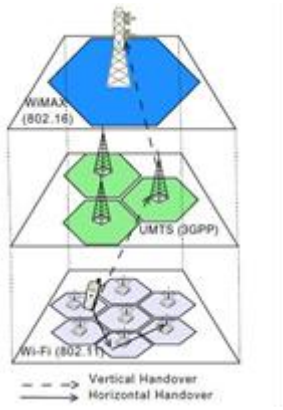


Fig. 1. Differences between Vertical and Horizontal Handover

2.5. Received Signal Strength Indicator (RSSI)

In vertical handover, the most traditional algorithm is based on the physical layer parameters such as Received Signal Strength (RSS) [3]. Horizontal Handover regularly uses RSSI to decide handover [4]. Apart from that, vertical handover is slightly different with horizontal handover. In handover, RSSI is a crucial parameter in the algorithm as the RSSI selects the network that available before deciding to handoff.

3. Methodology

Waterfall research method is applied for this work. The model is chosen since the idea of waterfall method that is known for its one-time execution models. The waterfall method has been derived to suite the work and has five phases consisting of system requirement, analysis, simulation design, algorithm, implementation and testing.

3.1. Simulation Design Phase

A simulation design phase is where the cells of different 4G networks is developed. A network requirement for each technology is applied based on the standard that has been set either by 3GPP or IEEE 3. Different BS will be simulate containing two LTE-A technologies and one 4G WiMAX. A user equipment (UE) will be simulated going through three BS. The diagram below explains how the simulation has been done.

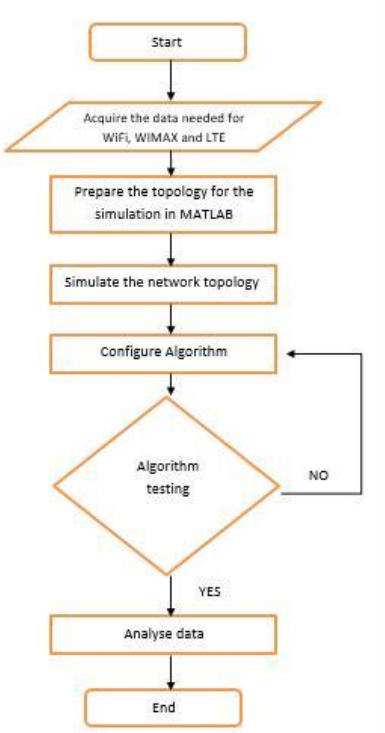


Fig. 2:. Simulation Process Diagram

For the simulation scenario, three different cells with different sizes are equipped with three different mobile technologies namely, LTE-A, 802.16 WiMAX and 802.11 WiFi that act as a base station. One moving user that moves in a straight line across three different base station as shown in Fig.3. Tab. 2 shows the simulation parameters that is used in this simulation.

3.2. Algorithm Implementation Phase

In this phase, an algorithm is picked to be used in order to carry out the objective. The algorithm is picked using the Vertical Handover Decision (VHD) standards. The standard is used to allow heterogeneous network to interconnect to each other mainly to overcome HO failures and unnecessary HO.

Table 2: Summary of Research Environment Parameters

Parameter	Value

Number of Cells	3
Number of UE	1
Cells radius	300,300,600 (WiFi, LTE,WiMAX)
Threshold	-125, -97, -110
Simulation time	150 secs
Simulation plane size	3000 * 2000

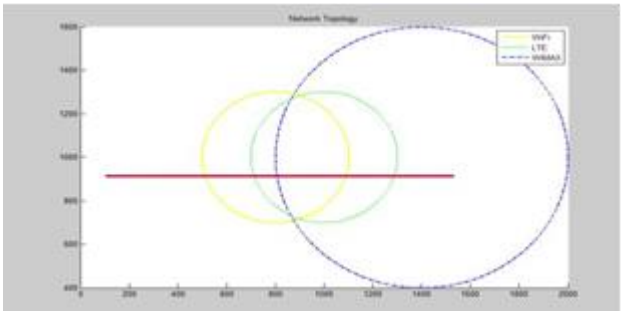


Fig. 3:. Simulation Plane Scenario of Handover

3.3 Testing Phase

After completing all the previous phases, testing on the simulation is carried out to test on how the algorithm works between 4G LTE and 4G WiMAX. A series of analysis on the HO failures rate and unnecessary HO rate is extracted. Conclusion is carried out based on the data extracted and this will allow the study on the efficiency of the HNE algorithm between 4G LTE and 4G WiMAX during HO.

4. Result Discussion

The user is moving almost to the centre of the cells in which the base station is located. Threshold for the UE was being set in order to see any changes in signal strength. The value of signal strength is varying since the user roams across the boundaries of the base station as well as across different networks. Fig. 4 shows the RSS threshold is detected by the UE for three different networks.

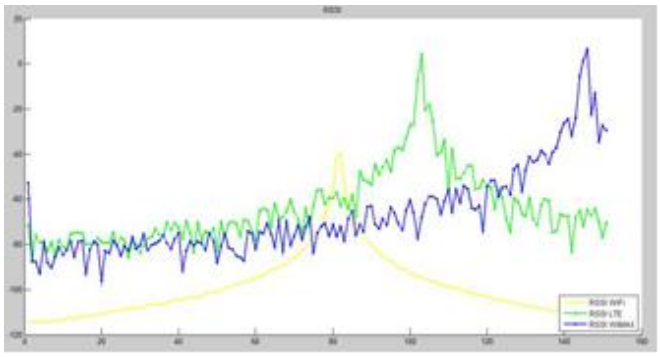


Fig. 4:. RSSI Threshold Against Time

Although UE detected three different networks from the beginning of simulation time, the handover only happened if UE detected the strongest signal. From the graph above, we can conclude that the signal strength of the base station to the user is determined by the location of the user and neighbouring base station. In the simulation plane, UE is moving across the networks by analysing the changes of RSSI threshold that has been set earlier between the time of 80-100 seconds that the user approached the centre of WiFi cells. User approached LTE cells between 100-120 seconds and the user reach peak RSSI between 120-150 seconds for WiMAX cells. Fig. 5 illustrates on number of vertical handovers occurred in the simulation.

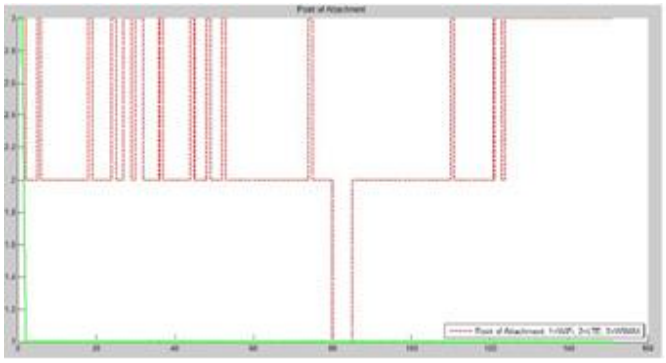


Fig. 5: POA of UE Against Time

The graph in Fig. 5 illustrates the position of attachment of UE against time. Here, we can see that UE hardly stays inside the LTE network and spend most of the time inside IEEE 802.16 WiMAX rather than LTE-A. Based on the RSSI graph in Fig. 4, the result of point attachment is based on the threshold that is being set earlier. The handover only occurs if the RSSI value meets at the peak with the UE. Thus, ping-pong handover is avoided and RSSI signal strength will determine the strongest signal to the user before handoff.

The simulation was tested few times in order to test the RSSI values that may change over time. There are some changes in the RSSI values detected by the UE in the simulations. Fig. 6 shows the changes in RSSI values detected by the UE for WiFi in which it does not reach the max RSSI. The RSSI value must be at peak to achieve the handoff The attachment of network to the UE is represented in Fig. 7.

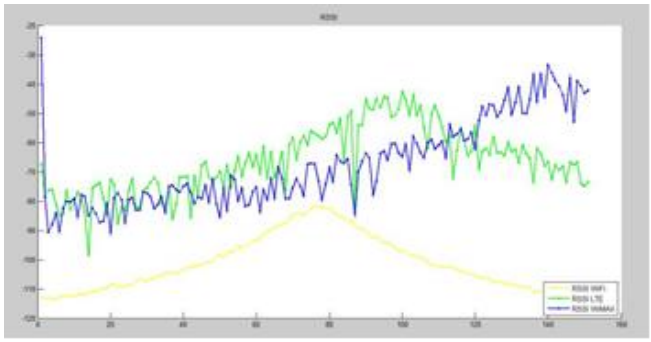


Fig. 6. RSSI Threshold Against Time

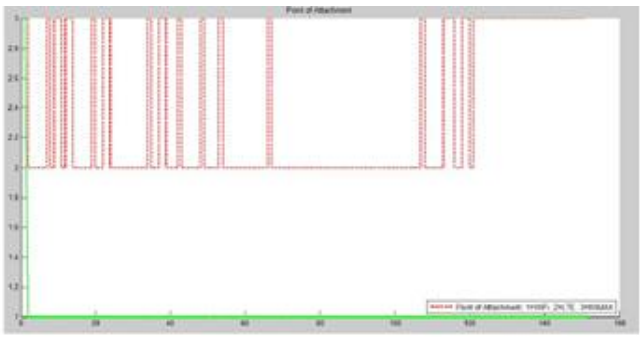


Fig. 7: POA of UE against time

Fig. 6 and 7, clearly note that the RSSI value in Wi-Fi network does not reach to the max, thus there is no handover being done and for the graph in Fig. 7. The changes at around 80 seconds that the UE does not attach to the Wi-Fi network.

5. Conclusion

Based on the output of the work, two different graphs were produced which provides different data. Furthermore, it can be con-

cluded that RSSI signal strength is based on the UE position on the network and UE will determine the best signal received in order to prevent ping-pong handover and unnecessary handoff between networks. Thus, the problems in heterogeneous network can be avoid by using RSSI criteria decision technique.

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