Speed Effect on the Performance of Vertical Handover in Wifi-3G Network

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***Abstract* - Mobile communication systems experienced high technical revolution. Nowadays, smart mobile devices have advanced computing aspects. In addition, they are provided with multiple network interfaces, wifi and 3G. Traffic redirection between these networks is addressed by the vertical handover process. Recently, vertical handover enhanced by the IEEE802.21 standards which enables seamless mobility and interworking between most of the heterogeneous wireless access networks [2]. A comparative performance study is done in this paper for the integration between WiFi and UMTS networks by taking advantage of the IEEE802.21 standard. The factors that affect the vertical handover process in this integration were studied such as the mobile speed, and the application bitrate. Selecting five mobile node speeds 5,10,25,50,60 km/h whereas application bitrate is 64 kb/s and 3840 kb/s.**

Keywords - MIH, IEEE802.21, performance, LGD, handover latency, modelling, curve fitting.

I. INTRODUCTION

The handover between access points and networks using same radio technology is denoted as Horizontal Handover [2]. Vertical handover defined as a process that enables the mobile node to redirect traffic flow between network interfaces based on obtained facilities from different wireless access networks [3]. This study represents the integration between WiFi and UMTS as heterogeneous technologies. The integration between two access networks from two different categories, wifi from the 802 family of standards and umts as 3G cellular network, is analyzed using the Media independent handover (MIH). MIH bridges the gap for integrating technology dependent networks by providing a global view of all the heterogeneous candidate networks to the mobile node [2]. Different network performance metrics will be calculated during the vertical handover process which describe the vertical handover process and the effect on the service continuity for the application running on mobile agents. The performance of this integration may not satisfy the Quality of Service (QoS) requirements for some applications which is recommended by the International Telecommunication Union – Telecommunication ITU-T [4].

To achieve the goal of Always Best Connected (ABC); vertical handover challenges should be considered and expressed in the integration between heterogeneous wireless networks. In ABC scenario the mobile node is not to be only always connected, but also being connected in the best possible way. Received Signal Strength (RSS) is the basic indicator that is measured in this stage in both horizontal and vertical handovers. But in vertical handover, it is useful to combine RSS with other indicators or parameters such as cost and bandwidth to form multi criteria indicator and decide to handover accordingly. This mechanism is addressed by multi criteria decision algorithms that consider decision parameters such as network conditions and user preferences in order to select the best candidate network.

Handover is consist of three stages the initiation, decision, and execution stage. Fig.1. represent the stages and the definition for each stage. In this study we will measure the Received Signal Strength (RSS) and accordingly the decision to do handover.

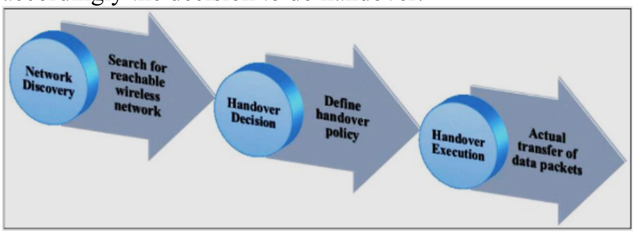

Fig.1.Handover phases.

II. RELATED WORKS

The research in [3] proposed an algorithm called Multi Criteria Selection Algorithm (MCSA) to consider additional parameters in addition to the RSS criterion implemented in Network Simulator-2 (NS-2) to select the best candidate network among WiFi and WiMAX. The available bandwidth, mobile node speed and the impact of network type were studied as multi criteria to improve QoS. Packet loss ratio and handover latency was studied as evaluation metrics. However, the performance metrics of the system under the effect of mobile speed and application bitrate was not modelled. In addition, this study does not consider the UMTS and WiFi network. Throughput and delay were not measured for the vertical handover scenarios. The performance of vertical handover is evaluated between WiFi and WiMAX using IEEE802.21 for different traffic flows

[8]: Voice over Internet Protocol (VoIP), video streaming and File Transfer Protocol (FTP). The performance metrics used for this evaluation include throughput, end-to-end delay and packet loss rate. The performance evaluation is done using the Network Simulator NS2.

In [5], the authors classified the network selection stage into three categories; network-centric, user-centric and collaborative schemes. Multi criteria decision algorithms based on cost function were proposed for handover between WiMAX and WLAN.

However, the proposed solutions focused on specific parameters and lack of detailed implementation in the MIH standard.

III. METHODOLOGY

The simulation tool used in this work is NS-2 version 2.29.3. Which contains an implementation of the MIH standard IEEE (802.21) [2][6]. Vertical handover scenarios between WiFi and UMTS were implemented using Tool command language (Tcl) in NS2 and configuring specific simulation parameters [2].

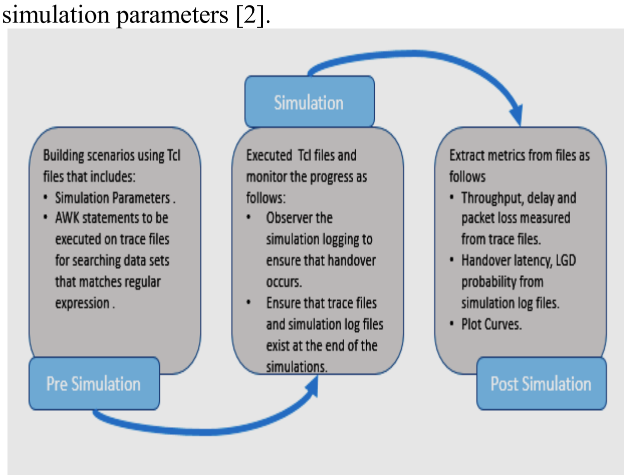

Fig.2.Simulation Phases

QoS evaluation was observed using performance evaluation metrics.

TABLE I. SIMULATION PARAMETERS FOR UMTS AND WIFI [1][3]

WiFi Parameters	
Coverage area	100 m
MAC Type	Mac/802_11
Frequency	2.41 GHz
Transmission Power	0.027 W 14.3 dBm
Bandwidth	11 Mb/s
RXThresh	2.64504e-10 W
CSThresh	90% of RXThresh
Weighted-Thresh	3.174048e-10 W
Antenna model	Omni Antenna
Pr_limit	1.2
UMTS Parameters	
Coverage area	1000 m
Frequency	2000 MHz
Bandwidth DL/UP	384 kb/s (outdoor)
Transmission Time Interval (TTI)	2 ms

Table 1 shows the simulation design parameters defined before running the simulation. These parameters include global parameters defined for all scenarios [3]. Each wireless access network has its own technology dependent parameters.

IV. VERTICAL HANDOVER SCENARIO

In this study, the infrastructure network consists of mobile node connected to a server as shown in Fig.3.

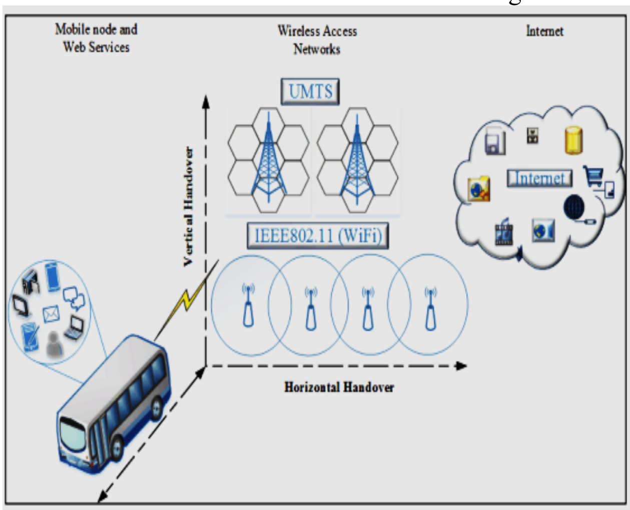

Fig. 3. Simulation Scenario.

A mobile node is located in the WiFi network which is the serving Point Of Attachment (POA) and is leaving this network towards the UMTS network which is the Candidate POA. This paper evaluates the effect of mobile node speed on the performance of running applications in this vertical handover scenario. Regarding traffic, we considered two applications; Voice Over IP (VOIP) traffic with bitrate 64kb/s and video traffic with 3840kb/s. Moreover, we selected five mobile node speeds 5, 10,25,50,60 km/h.

In all scenarios, the mobile node travelling distance is constant and includes the vertical handover area. In each scenario we set one mobile node speed and one application bitrate to be fixed during the whole simulation time. As a result, we got five trace files one for each speed that include all sent and received packets between the server and both WiFi and UMTS interfaces on the mobile node. For each scenario, we extract our network performance metrics such as average throughput, packet loss ratio and delay. In addition, the simulation log files show an important information about handover time and MIH messages that resulted in measuring handover latency.

For example, when the mobile node moves from WiFi to UMTS with speed 5km/h and VOIP application (64kb/s) is running, the average throughput on WiFi interface is (63.862 kb/s) while in UMTS it is (63.942 kb/s). On the other hand, when the speed increase to 60km/h the average

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throughput on WiFi degrades to (44.494 kb/s) which means it degrades by (69.5 %) as shown on the normalized average throughput fig.7.

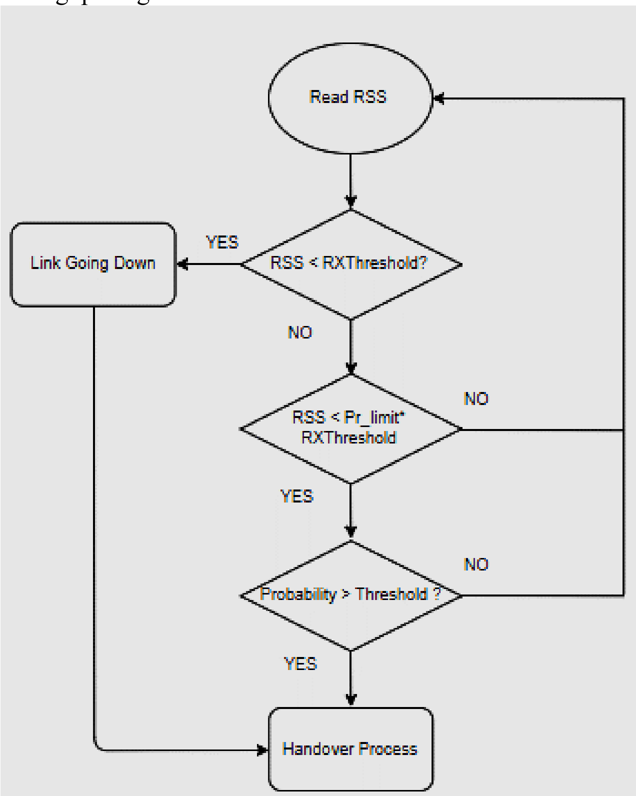


Fig.4.Handover process based on signal power flowchart

Performance Evaluation Metrics:

- Average Throughput: Total data delivered to destination within time interval measured in kb/s [1].

$$\text{Average Throughput} = \frac{\text{Total data delivered (kb)}}{\text{Time in access network (s)}} \quad (1)$$

$$\text{Normalized Throughput} = \frac{\text{Average Throughput}}{\text{Bitrate}} \quad (2)$$

- Received Packets: total number of packets arrived to destination node.
- Packet Loss Ratio: it is an indicator of the total amount of packets that is not successfully delivered to destination from the total send packets during the time interval [3].
- End to End Delay: is the time needed for a packet to reach its destination node from a source node [1].
- Handover Latency: is the amount of time that elapses between the first packet received on the mobile node interface in the destination or candidate network and the last packet received on the mobile node interface in the serving network [2].
- Power RSS: received signal strength power on the mobile node.

V. RESULTS AND DISCUSSION

The average throughput in WiFi and UMTS interfaces on the mobile node is measured as shown in Fig.5. We observe that the average throughput measured at low rate of 64 kb/s is not affected at a low speed of 5 km/h. It remains almost the same on both interfaces. However, when increasing the mobile node speed to (50-60 km/h) the average throughput start to decrease on the WiFi interface which means that there is a loss in the packets arrived to the WiFi interface. Fig.9 show the packet loss ratio at all speeds.

Average Throughput

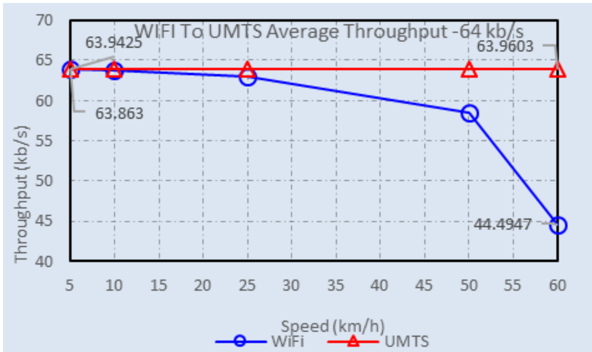


Fig. 5. Average Throughput on mobile node WiFi and UMTS interfaces for application with bitrate 64kb/s.

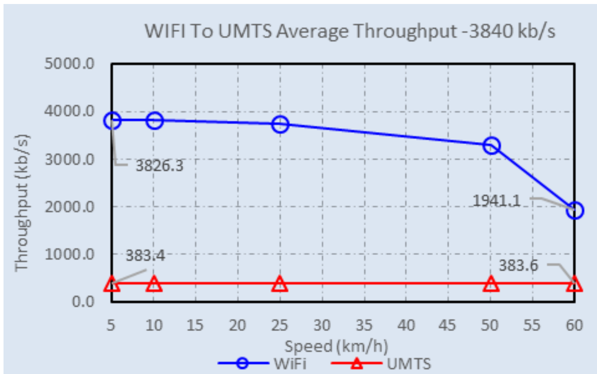


Fig. 6. Average Throughput on mobile node WiFi and UMTS interfaces for application with bitrate 3840kb/s.

The results in fig5. and fig.6 show that there is no change in the average throughput in UMTS network when we change the mobile speed. The speed remains almost the same because of going to that network with stronger RSS power.

Normalized throughput in Fig.7 is measured to observe the effect of speed when the mobile node is using application with a specific bitrate. The throughput is taken at two values of application bitrate. From the result we notice that at speed 5 km/h for both bitrates we get 99.8% of the average throughput, but by increasing the speed to 60 km/h we get

69.5% and 50.5% of average throughput for 64 kb/s and 3840 kb/s respectively.

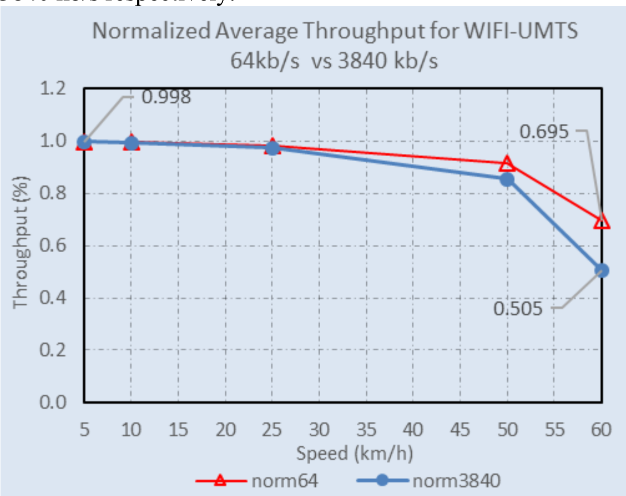


Fig.7. Normalized Throughput

Received Packets

As a result of increasing the speed of the mobile node as shown in Fig.8. We notice a degradation in the total packet received to the mobile node. Because the mobile node is leaving the coverage area of the WiFi, node RSS is decreased when the mobile is leaving toward the UMTS network. In addition, the total time spent inside WiFi network becomes shorter with increasing mobile speed. Therefore, the total amount of data received at the WiFi interface is decreased.

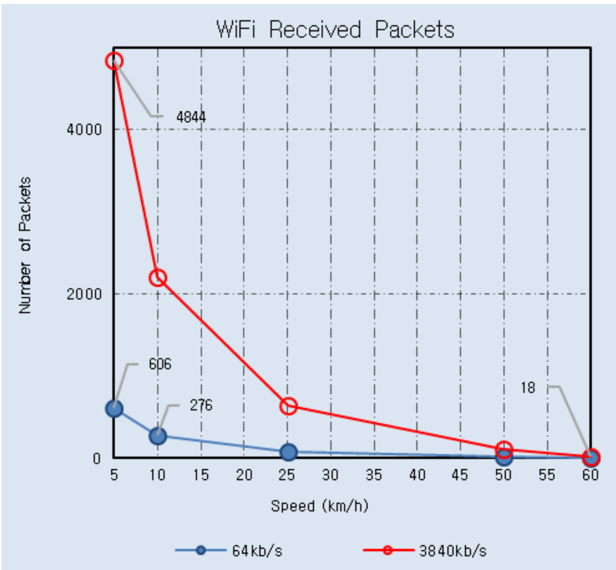


Fig.8. Total Packets Received on UMTS interface for two applications with bitrate 64kb/s and 3840 kb/s.

From the packet loss ratio shown in fig.9, we observe that at both bitrates in the WiFi network and at slow speed that the packet loss is very close. However, packet loss ratio is more affected on high speed and it reach around 72%. On the other hand, the packet drop in umts at the high data rate applications is 90%, because of the limitation of this technology which have 348 kb/s bandwidth only [10][11].

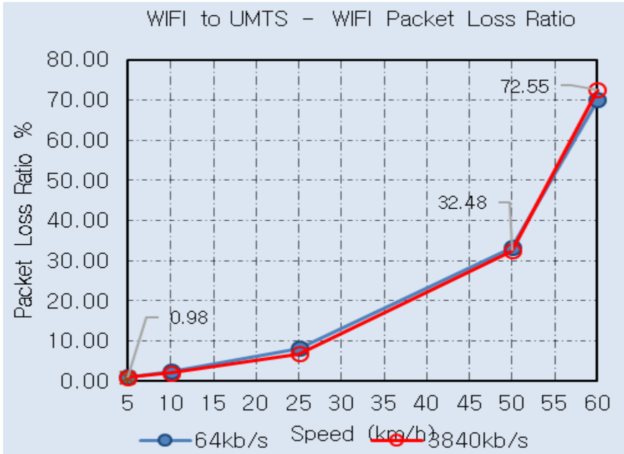


Fig.9.Packet Loss Ratio on WiFi network

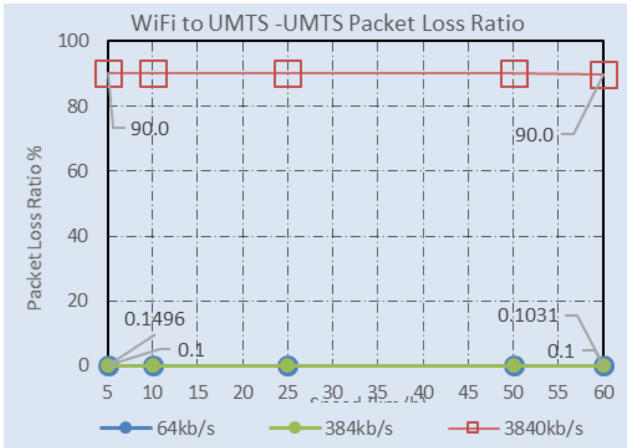
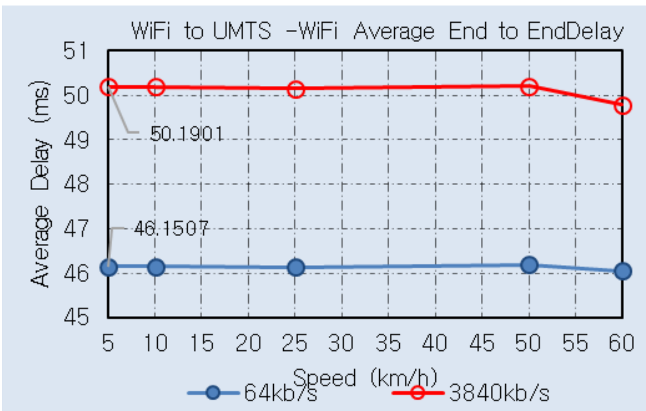


Fig. 10. Packet Loss Ratio on UMTS network



Delay
Fig. 11. Average End to End Delay in WiFi network

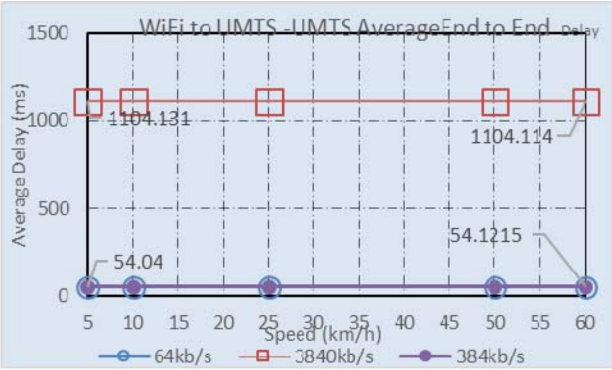


Fig.12. Average End to End Delay in UMTS network

The time needed for the packet to arrive from source node which is media server in the scenario to WiFi or umts interface in the mobile node The sum of these delay intervals divided by the number of received packets is the average E2E delay. From fig.11. and fig.12 Observed that increasing the mobile speed and the bitrate in the WiFi network will slightly increase the average end to end delay. However running a high bitrate application 3840 kb/s gives a high end to end delay in the UMTS network 1104 ms . On the other hand, bitrate less than 384 kb/s will insure the service continuity for the application giving a low end to end delay 54.04 ms.

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Handover Latency

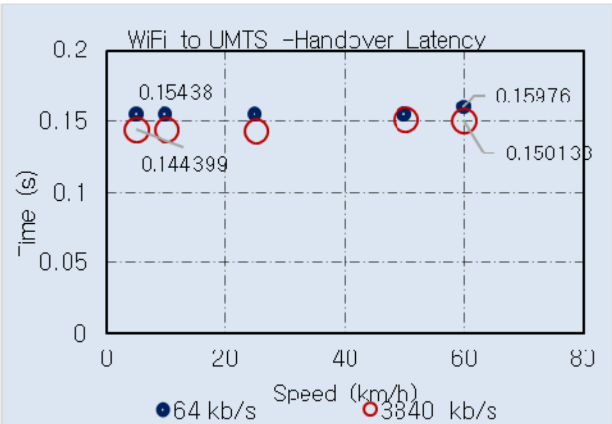

Fig 13. Handover Latency from WiFi to UMTS network

It is the time needed for the mobile to do the handover process during the movment from wifi to umts . Noticed from fig.13.that the effect of the speed on handover letancy is small since when moving in the speed of 5km/h and 60 km/h the letancy increase from 144 ms to 150 ms when running 3840 kb/s application.

Power Vs Time

Moving the mobile node faraway from the wifi access point will caused a digradation in the recived signal strenght power on the mobile node [7]. Fig.14. represent the the recievied signal strenght power in the wifi area while the mobile node is moving from wifi to umts network.Starting the handover intiaion stage will become earlier when moving the mobile node with high speed . To prevent RSS power on mobile node to reache the RX-Threshold and caused a service continuity problem Link Going Down (LGD) probability which included in the media indpendent handover MIH standard as a link event service will be calculated when the mobile RSS power reaching the weighted threshold which defined as Prlimit multiplied RX-Threshold LGD probability increses while the increasing the speed of the mobile because the time reaching the weighted threshold area is more earlier[5].

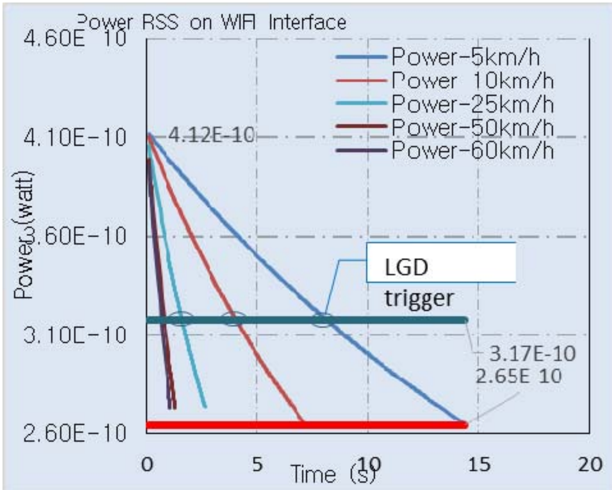

Fig.14. Power RSS measured on the mobile node WiFi interface while it is leaving WiFi network.

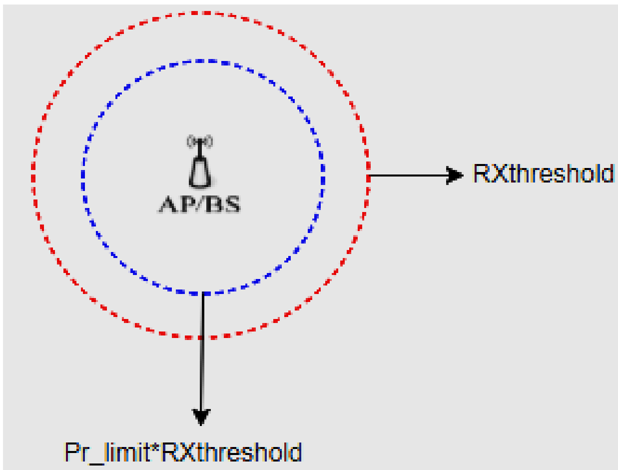

Fig.15.Signal Strength threshold.

TABLE II. RESULT SUMMARY

Metric \ Scenario	WiFi to UMTS: WiFi	WiFi to UMTS: UMTS
Throughput	Exponentially Decreases with the increase of speed.	Not affected by increasing speed and bitrate for bitrate < 384 kb/s. Exponentially Decrease for bitrate > 384 kb/s.
Throughput	Acceptable values for speed < 50 km/h	Acceptable values for bitrate < 384 kb/s
Data Received	Decreases with increasing speeds. Increase with increasing bitrate	Slightly Increases with increasing speed. Increase for bitrate < 384 kb/s Constant for bitrate > 384 b/s
Total Packet Loss Ratio	increases with increasing speed for bitrate > 384 kb/s Almost constant with increasing speed for bitrate < 384 kb/s	
Total Packet Loss Ratio	Acceptable values only for bitrate < 384 kb/s	
Average E2E Delay	Slightly increases with increasing bitrate. Not affected by speed.	Exponentially increase for bitrates > 384 kb/s Not affected by speed.
Average E2E Delay	Acceptable values for all bitrates.	Acceptable value for bitrate < 384 kb/s Very high value for bitrate > 384 kb/s
Handover Latency	Slightly affect with increasing bitrate. Not affected by increasing speed. Affected by the direction of mobility.	
Handover Latency	Acceptable values from 142 ms to 167 ms when handover to UMTS	

VI. MODELLING

In order to obtain a functional description for the behavior of the obtained results, curve fitting with various models was carried out. Curve Fitting Toolbox in MATLAB[9] was used to select the best model that represents the behavior of the results among the candidate models supported by this toolbox Curve fitting was done for two curves in each evaluation metric, these two curves represent the minimum and maximum curves which is the 64 kb/s and 3840 kb/s bitrates.

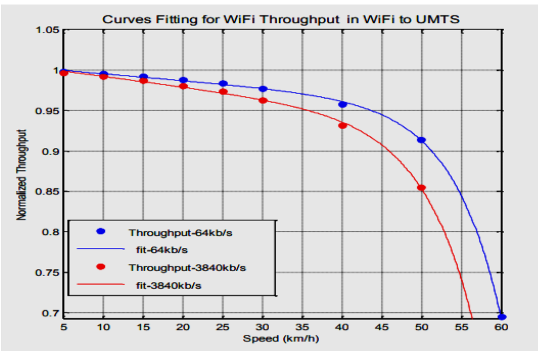

Fig.16.Curve Fitting

The results of the WiFi Normalized Throughput in WiFi to UMTS scenario were shown in Fig 3. The minimum curve (3840 kb/s) and the maximum curve (64 kb/s) were selected for fitting. Figure 14 shows the actual data for each bitrate and the curves that fit with these data. The function of the fitted curves was of type exponential as shown in equation: -

$$f(x) = a * e^{(b*x)} + c * e^{(d*x)} \quad (3)$$

Coefficients for 64 kb/s: $a = -1.296 * 10-5$ $b = 0.1651$ $c = 1.004$ $d = -0.0008415$

Goodness of fit for 64 kb/s: $R2 = 0.9997$ $SSE = 1.99 * 10-5$ $Adjusted\ R2 = 0.9996$ $RMSE = 0.001995$

VII. FUTURE WORK AND CONCLUSION

The integration between wireless heterogeneous networks are becoming an emerging issue[10]. Recently, smart mobile phones have high computing capabilities and therefore the demand on seamless mobility with achieving QoS requirements has increased. Modern applications are developed to provide high quality service to mobile users, some of them are QoS aware applications such as voice and video services. Furthermore QoS requirements depends on the usability of the applications [4] . It is important to address the multi criteria decision algorithms in vertical handover because the obtained results in this research showed that in addition to the RSS tradition criterion that is used in horizontal and vertical handover, the information about the mobile node speed and application bitrate will enhance the handover process and help improve the QoS. There are other important criteria that may be used, such as network cost, user preferences and power consumption.

REFRENCES

[1] "IEEE Standard for Local and Metropolitan Area Networks- Part 21: Media Independent Handover," IEEE Std 802.21-2008, vol., no., pp.c1-301, Jan. 21, 2009.

[2] National Institute of Standards and Technology (NIST), "The Network Simulator NS-2 NIST mobility package add-on,", March 2009.

[3] A. Rahil, N. Mbarek, O. Togni, "Smart Network Selection and Packet Loss Improvement during Handover in Heterogeneous Environment", in Proc. of ICNS 2013, Lisbon, March 2013.

[4] Abedelaziz K. Nasim, H,L.A,S,B, "Trade off Analysis for Vertical Handover Between UMTS-WiF Enhanced by IEEE802.21", IEEE, RFM. Jan, 2013.

[5] Aggeliki Sgora, Christos A. Gizelis, Dimitrios D. Vergados, Network Selection in a WiMAX–WiFi Environment, Pervasive and Mobile Computing, Volume 7, Issue 5, October 2011, Pages 584-594, ISSN 1574-1192, 10.1016/j.pmcj.2010.10.001.

[6] Omar, K, Omar, A, "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.3, September 2013.

[7] Fernandes, S., Karmouch, A., "Vertical Mobility Management Architectures in Wireless Networks: A Comprehensive Survey and Future Directions", Communications Surveys; Tutorials, IEEE,vol.14, no.1, pp.45, 63, First Quarter 2012.

[8] Chih-Peng Lin, Hsing-Lung Chen, and Jenq-Shiou Leu, "A Predictive Handover Scheme to Improve Service Quality in the IEEE

802.21 Network", Computer & Electronics Eng. 38, 3 May 2012, 681- 693.

[9] Mariem, T, Nabil, T., "Vertical Handover between WiFi Network and WiMAX Network According to IEEE 802.21 Standard", Springer Science, DOI 10.1007,2010.

[10] Matlab: www.matlab.com/curvefitting.

[11] T. Janevski, K. Jakimoski, "Improving Vertical Handovers for Real-Time Video Traffic between UMTS and WiMAX Networks", International Journal on Research and Reviews in Next Generation Networks, Vol. 1, No.1, March 2011.

[12] McNair, J.; Fang Zhu, "Vertical Handoffs in Fourth-Generation Multi Network Environments" Wireless Communications, IEEE, vol.11, no.3, pp.8, 15, June 2004.