Journal of Theoretical and Applied Information Technology
20th September 2015. Vol.79. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

PERFORMANCE ANALYSIS OF SEAMLESS VERTICAL HANDOVER IN 4G NETWORKS

[1]IZZELDIN I. MOHAMED, [2]AMRAN A. HADI, [3]MD R. OTHMAN, [4]A. OUDAH
[1,2,3]Faculty of Electrical and Electronics Engineering, Universiti Malaysia Pahang
[4]Faculty of Manufacturing Engineering, Universiti Malaysia Pahang
E-mail: [1]izzeldin@ump.edu.my, [2]amranhadi@ump.edu.my, [3]rizal@ump.edu.my, [4]oudah34@gmail.com

ABSTRACT

The current extraordinary growth of wireless technology promises an even greater effect on how people communicate, interact and enjoy their entertainment. The growing advances in research and development of wireless communication technologies and the increasing capabilities of electronic devices are driving an evolution towards ubiquitous services to mobile users. Wireless networks become increasingly interoperable with each other and with the high-speed wired networks. This reflects a paradigm shift towards new generations of mobile networks where seamless mobility across heterogeneous networks becomes fundamental. This generation is referred to as fourth generation (4G). 4G wireless networks is envisioned as a convergence of different wireless access technologies providing the user with the best anywhere, anytime connection and improving the system resource utilization. With the advent of new value-added services (video-conference, multimedia streaming, etc.) and novel concepts introduced into Long Term Evolution (LTE) architecture of the 4th Generation (4G) networks, provisioning efficient mobility management with quality of service guarantees and seamless handoff feature become even more important for next-generation wireless network design. Vertical handover, a term used to indicate the handover between two access nodes of two different technologies, is an issue in heterogeneous networks since each technology has its own mobility management solution. Generally, multimedia applications, one of main services in 4G networks, require a short handover latency, low jitter and minimal packet loss. Handover is required to be achieved seamlessly to enable the users want to have a continuous and qualified service regardless of which access technology they have connected. The aim of this work is to present research outcomes including an analysis of UMTS/WLAN integration and the performance of common applications. The work included the development of a model and simulation environment that could be used to gain results suitable for analysis. Specific attention was paid to design tight coupling and loose coupling architectures as this work direction taken was to identify an architecture that can provide better overall performance and flexible interworking. Our results show that tight and loose coupling have advantages depending on the application. For video conference loose coupling provides lower jitter and end to end delay. Tight coupling was found to provide a lower response time for an http page application. Tight coupling was also provides a lower response time for ftp file uploads however to download ftp files loose coupling provides a lower response time.

Keywords: *4G Network, Vertical, Handover, Wireless, Seamless*

1. INTRODUCTION

The evolution of the Internet and the advances in wireless access networks and devices have made a tremendous impact on people lifestyles around the world, the current extraordinary expansion of wireless technology promises an even greater effect on how people communicate, interact and enjoy their entertainment. The growing advances in research and development of wireless communication technologies and the increasing capabilities of electronic devices are driving an evolution towards ubiquitous services to mobile users. Wireless networks become increasingly interoperable with each other and with the high-speed wired networks. This reflects a paradigm shift towards new generations of mobile networks where seamless mobility across heterogeneous networks becomes fundamental. This generation is referred to as fourth generation (4G) [1, 2].

Nowadays, it is widely agreed that no single technology is able to meet the known and the

Journal of Theoretical and Applied Information Technology
20th September 2015. Vol.79. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

future challenges in the telecommunication domain. At the contrary, the research community considers that future solutions will be based on the coexistence of multiple heterogeneous technologies. In the context of heterogeneous wireless networks we do not have a set of formally agreed end-to-end standards developed in the traditional top-down way that the telecommunications industry has used for years. Heterogeneous wireless networks are subject to multiple air interfaces and various mobile terminals with multi-homing capabilities that are intended to provide mobile users with a good Quality of Service (QoS), high bandwidth and low cost. It is based around five main elements to offer a personalized and pervasive network to the users: availability at anytime and anywhere, seamless mobility, affordable cost, uniform billing and convergence of networks, technologies and services [3, 4].

Heterogeneous wireless networks may incorporate Wireless Local Area Networks (WLAN), Wireless Personal Area Networks (WPAN), Wireless Metropolitan Area Networks (WMAN) and Wireless Wide Area Networks (WWAN) including cellular networks and satellite. The main promise of these heterogeneous networks is to provide high performances by achieving high data rate and supporting video telephony, streaming and multicasting with high QoS. The characteristics of these different networks are illustrated in Table 1

As nowadays users required to be connected through different available access networks when they move from one place to another (at home, in the office, on the bus, on the train, in the shopping mall, in the cafe...). Continuity of Service for these users on the move has been always a target for different network providers and device producers, since the first generation of radio technologies. New multimedia services with strict quality of service requirements have emerged like video on-demand or high resolution television. At the same time different technologies was launched on the market (e.g. IEEE802.11, IEEE802.16, and Bluetooth) each with its own pros and cons, e.g. high data rate but reduced range [5].

With a plethora of services and technologies, the main challenge is no longer to be “always connected" to a service but instead to be “always best connected" (ABC). ABC paradigm has only recently been introduced to indicate the possibility for a user to be always connected to the “best" network using the “best" device that can support the desired service(s). It should be noted that the notion of “best" is relative and, in some cases, subjective to the context and may include different aspects like cost minimization and quality of service constrains successfully respected. Among the procedures that permit the fulfilment of ABC is possible to identify the Mobility Management and, more in particular, the handover among heterogeneous networks (i.e. Vertical Handover, VHO).

TABLE 1: Wireless Technology Features Comparison

Network	Standard	Data Rate	Frequency band
Cellular Networks	UMTS 3G	Up to 2 Mbps	1990-2025 MHz
	4G	100 Mbips-1 Gbps	
WLAN	IEEE 802.11b	1-11 Mbps	2.4 GHz
	IEEE 802.11n	100-540 Mbps	2.4, 5GHz
Wireless Personal Area Networks (WPAN)	IEEE 802.15.3	11-55 Mbps	2.4 GHz
Zigbee	IEEE 802.15.4	20-250 Mbps	868, 915 MHz
Wireless Metropolitan Area Networks (WMAN)	IEEE 802.16a	75 Mbps	2-11 GHz
WiMAX	IEEE 802.16c	134 Mbps	10-66 GHz
Wireless Wide Area Networks (WWAN)	IEEE 802.20	2.25-18 Mbps	3.5 GHz

Vertical handover, a term used to indicate the handover between two access nodes of two different technologies, is an issue in heterogeneous networks since each technology has its own mobility management solution. The mobile terminal must be capable of adapting the service content and the communication parameters each time it changes the access network. The two most considered performance criteria for the handover design are latency and packet loss. Generally, multimedia applications, one of main services in 4G networks, require a short handover latency, low jitter and minimal packet loss. Handover is required to be achieved seamlessly. It means that handover is transparent to user’s experience: users do not recognize handover occurrences at the application perception. Technically, it means that the handover interruption delay should be very small (below

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

50ms) and the packet loss ratio should be minor to not affect the service quality (tolerant loss ratio differs from different application types). Users want to have a continuous and qualified service and they do not care about which access technology they have connected [1, 5].

This paper addressed this problem by analyzing the integration between Universal Mobile Telecommunication System (UMTS) and Wireless Location Area Network (WLAN) during handover process and evaluated the impact of seamless vertical handover on the system performance in terms of delay, throughput and packet loss. Two integration scenarios for Open and Loose coupling scheme were designed. Our results show that tight and loose coupling have advantages depending on the application. For video conference loose coupling provides lower jitter and end to end delay. Tight coupling was found to provide a lower response time for an http page application. Tight coupling was also provides a lower response time for ftp file uploads however to download ftp files loose coupling provides a lower response time.

In section 2, some related work are presented. Then, the handover management in UMTS/WLAN is discussed in section 3. Consequently, the integration of UMTS/WLAN are discussed. Then, a proposed scheme of network selection and handover decision is presented. In section 6, the performances of the proposed scheme are computed and compared. Finally, conclusions are made in section 7

2. RELATED WORK

Numerous proposals and approaches considering the vertical handoff schemes and decision algorithms were proposed in the literature. Some of approaches were based on "Received Signal Strength (RSS)" that may be combined with other parameters such as network load and network cost. Others were using artificial intelligence techniques, combining several parameters such as network conditions and Mobile Terminal's (MT) mobility in the handoff decision [6]. Some were policy based approaches, combining several metrics such as access cost, power consumption, and bandwidth, velocity of a host, quality of service in VHO mechanism. In [7], an efficient decision handoff mechanism for heterogeneous network is proposed. the defined a new system-wise entity that is activated when a user is in an area with overlapping access technologies and needs to decide the best technology to be used, where the entity performs technology selection in order to optimize the overall system performance metric in terms of throughput and capacity limitation. Their simulation results validate the efficiency of their method and show that it is also applicable to other combinations of access technologies. In [9], a Markov decision process (MDP) handover system is proposed. This work incorporated the connection duration and signalling load incurred on the network for VHO decision. Their numerical results show that the proposed MDP algorithm gives a higher expected total reward and lower expected number of vertical handoffs than SAW (Simple Additive Weighting) and GRA (Grey Relational Analysis).

A dynamic decision model for VHO across heterogeneous wireless networks is proposed in [6]. This model makes the right VHO decisions by determining the "best" network at "best" time among available networks based on dynamic factors such as RSS and velocity of mobile station as well as static factors. [8], proposed a theory for selection of the best available wireless network during handoffs based on a set of predefined user preferences on a mobile device. The proposed method is capable of selecting the best available wireless network with a reasonable performance rate.

The overall approach is based on artificial intelligence, combining some other metrics for decision model of VHO. In [10], implementation of a loosely coupled integrated network that provides roaming between 3G and WLAN networks was described. [11] presented yet another method to support roaming between 3G and WLANs by introducing a new node called the virtual GPRS support node in between the WLAN and the UMTS networks. Their approach showed a reduction in handoff latency compared to the Mobile IP approach.

In [12] three different internetworking strategies: the mobile IP approach were evaluated, the gateway approach and the emulator approach with respect to their handoff latencies. [13], discussed mobile IP based vertical handoff management and its performance with respect to signalling cost and handoff latency. In [14] the performance of vertical handoffs between IEEE 802.11b and UMTS in the case of Mobile IPv4 was analyzed. The paper concluded that handoff packet delay and throughput depends upon the number of WLAN users and the traffic generated by them.

Journal of Theoretical and Applied Information Technology
20th September 2015. Vol.79. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

3. HANDOVER MANAGEMENT IN UMTS/WLAN

The handover management is an essential process for any mobile network. It enables the network to keep active connections during the Mobile Terminal (MT) movement or even balance the network load evenly among different areas. Although its functionality and implementation differs amid the different technologies, some basic characteristics are common. One of the main goals of handover management is to sanctuary the communication quality during the handover of a MT. This is strongly related to the way the old links are released and the new ones are established. In this respect, two basic types of handover exist: the soft and the hard handover. A handover is identified as soft if at least one active link exists between the MT and any AP (old or new) during the entire handover period. If the MT has an active link with only one AP at a time, the handover is referred to as hard [15].

The handover process can be divided into three stages: initiation, decision and execution as shown in Figure 1 [16]. Handover initiation is responsible for triggering the handover according to specific conditions such as radio bearer deterioration or network congestion. During the handover decision stage, the decision for the most appropriate new Access Point (AP) is taken. At this stage several parameters (e.g., signal strength of neighboring APs, available radio resources, etc) are considered before a final decision is reached. Finally, at the last stage, the required signaling exchange for communication re-establishment and data re-routing through the new path is made. Figure 2 illustrates the vertical handover of UMTS/WLAN integrated networks.

UMTS infrastructure is divided into the Core Network (CN) and the Access Network (AN). The UMTS CN is further logically divided into i) the packet-switched domain (PS-domain), where packets are routed independently, ii) the circuit-switched domain (CS-domain), where dedicated resources are granted for voice calls, and iii) the IP Multimedia Subsystem (IMS) that provides IP multimedia services over the PS-domain. In the CN, the routing of data between the UMTS network and the external network is performed at the Serving GPRS Support Node (SGSN) via the Gateway GPRS Support Node (GGSN) for the PS-domain. Similar functionalities are performed at the Mobile Switching Centre (MSC) and the Gateway Mobile Switching Centre (GMSC) for the CS-domain. The Home Subscriber Server (HSS), which maintains the users' profiles, is common in both domains. The CN can connect to different types of ANs concurrently. An AN can be either a Base Station System (BSS), offering GSM/GPRS services to Mobile Stations (MSs), or a Radio Network System (RNS), accustomed for UMTS services to User Equipment's (UEs). A BSS consists of Base Transceiver Stations (BTSs) and one Base Station Controller (BSC) that are responsible for radio communications and radio resource control respectively. Similar functionalities are provided by the respective RNS entities, Node-Bs and the Radio Network Controller (RNC). The part of the network that consists of RNCs and Node-Bs is the UMTS Terrestrial Radio Access Network (UTRAN). The UMTS architecture with the interfaces between the respective network components is shown in Figure 3.

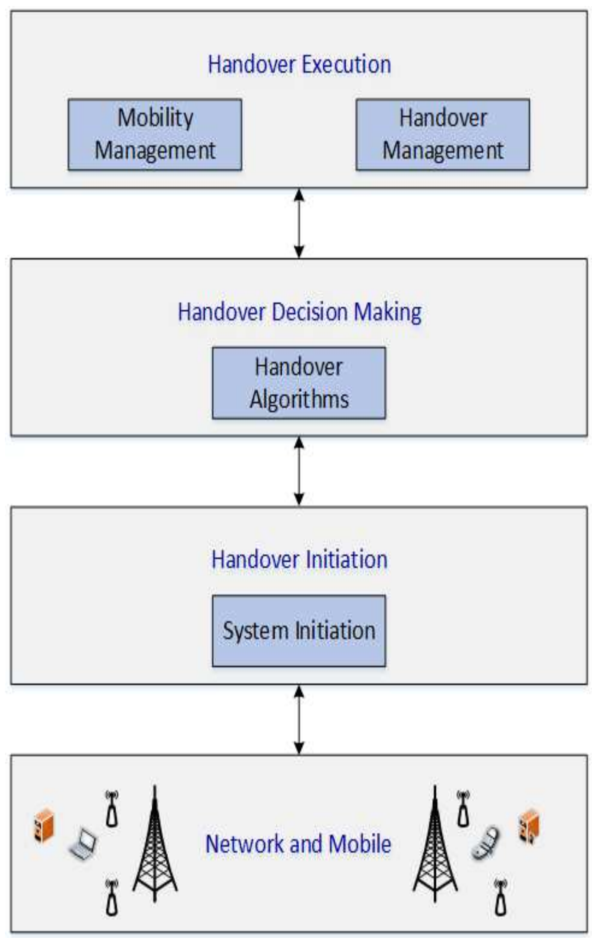

Figure 1: Vertical Handover Process

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

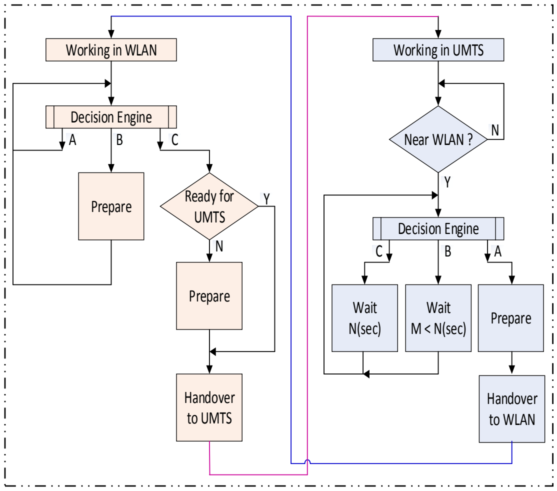

Figure 2: Vertical Handover Procedure between UMTS and WLAN

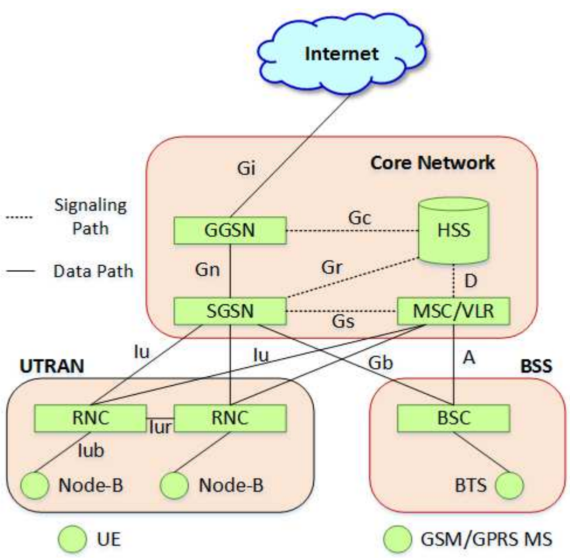

Figure 3: UMTS Architecture

In addition to the two basic handover types (i.e., hard and soft), UMTS also defines softer handover, utilizing the ability of the terminal to have two active communication paths (macro diversity) with the same access point [17]. Apart from the hard handover, when communication is abruptly lost, softer and soft handovers are performed in most of the cases. Softer handovers occur when the terminal moves within the area of the same Node-B (intra Node-B), while soft handover applies to the case of movement between different Node-Bs (inter Node-B/intra RNS), between different RNSs (inter Node-B/inter RNS/intra SGSN) and between different SGSNs (inter Node-B/inter RNS/inter SGSN). The UMTS handover procedure involves quite complicated protocols such as the Radio Resource Control protocol (RRC) [18]. RRC is responsible for cell selection, paging, UE measurements, RNS changes and control of radio bearers, physical and transport channels. Most of the RRC functionality is implemented in the RNC. In RRC, different functional entities handle the signaling to UEs, the paging and the broadcasting. Furthermore, some other protocols are also involved in the mobility procedure [19]. GPRS Mobility Management protocol (GMM) is used to support the mobility of the terminals [20]. Attach, routing area updates, detach, paging and authorization are only part of its functionality. GMM is placed on top of another signaling protocol, the Radio Access Network Application Part (RANAP), which is responsible for the establishment of different signaling channel to each UE.

On the other hand, handover management in WLANs is performed in a much simpler way. Since WLANs are IP-based networks, the Mobile IPv4 protocol (MIPv4) is widely used for handover management [21]. Its purpose is to maintain IP connectivity for the terminal after a movement to a different subnet. In MIPv4, the main functional entities are the Mobile Node (MN), the Home Agent (HA) and the Foreign Agent (FA). These are shown in Figure 4.

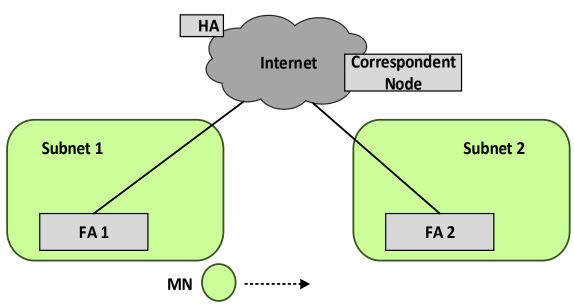

Figure 4: Mobile IP Architecture

As the MN moves between subnets, it obtains different temporary IP addresses (referred to as “care-of addresses”) and reports them to it’s HA, located at its home network. The role of the HA is to capture packets destined to the constant IP address of the MN and forward them to its current care-of address. Forwarding is performed through “tunneling”, a well-known IP technique where the original packet is encapsulated into a new packet with a new destination address (the care-of address). The FA, located at the visited network de-tunnels the original packet and delivers it to the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

MN. In the opposite direction, packets are routed directly from the MN towards its Correspondent Node. MIPv4 has further evolved into Mobile IPv6 (MIPv6) [22], where extended addressing, elimination of foreign agent necessity and route optimization capabilities have been included. The MIPv4 and MIPv6 protocols are mainly suitable for inter-domain mobility, due to intrinsic latencies in move detection and registration. For intra-domain mobility, a plethora of protocols that can perform fast handover have been proposed. HAWAII, Cellular IP and Hierarchical IP are only some of the representatives in this area [23].

4. INTEGRATION OF UMTS AND WLAN

Various scenarios where an integration of WLAN and UMTS can be advantageously exploited are possible. In this paper we are concentrating on the compensation for WLAN network lack of coverage through a UMTS back-up network. Namely, we consider the scenario in which a user is moving out of the coverage area of WLAN and exploits the UMTS network via the so called "Vertical Handover" process. UMTS and WLAN can be integrated in two different ways such as tight coupled and loosely coupled architecture.

UMTS and WLAN Networks can be integrated with different ways and strategies. The two most commonly used are tight and loose coupling architecture shown in Figure 5. Other architectures are modifications of these two basic ones. In tight coupling architecture, the WLAN network does not appear to the UMTS core network as an external packet data network. Instead, it appears simply as another UMTS Radio Access Network.

WLAN network in this case emulates several functions of the UMTS RAN. This is made possible by employing a specialized WLAN gateway in between the UMTS core network and the WLAN network that hides the details of the 802.11 network and implements all UMTS protocols required in the UMTS Radio Access Network. The architecture is capable of providing roaming services to users with dual stack (UMTS and 802.11) network cards in their mobile devices. Using this approach, both the networks often share common billing and authentication mechanisms. However, all traffic from the WLAN network passes through the UMTS core network, which could cause it to become a bottleneck.

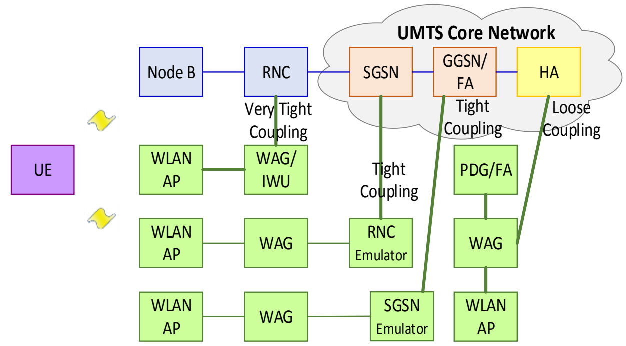

Figure 5: UMTS/WLAN Interconnection Approaches

Tight architecture also requires common ownership of the two networks that does not make it a very feasible deployment strategy. However, tight internetworking does offer high security mechanisms as the UMTS security protocols can be reused in the WLAN network. It also provides fast handoffs as roaming between the two networks is the same as moving between two RANs of the same UMTS network (since the WLAN network appears as a different Routing Area only).

In loose coupling architecture shown in Figure 6, the WLAN gateway directly connected to the Internet and does not have any direct link to UMTS network elements. In contrast to tight coupling, the WLAN data traffic does not pass through the UMTS core network but goes directly to the IP network (Internet). In this approach, different mechanisms and protocols can handle authentication, billing and mobility management in the UMTS and WLAN portions of the network. Loose coupling has low investment costs and permits independent deployment and traffic engineering of the WLAN and UMTS networks..

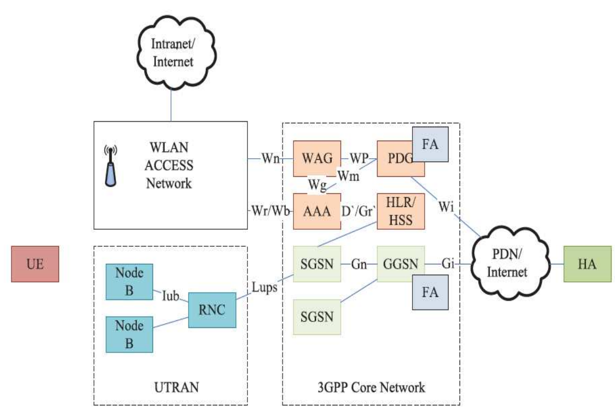

Figure 6: UMTS/WLAN Loose Coupling Architecture

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 2: Comparison of UMTS/WLAN Tight and Loose Coupling

Features	Architecture	
	Tight Coupling	Loose Coupling
Complexity of Deployment	Medium level of difficulty	High level of difficulty
Handoff Latency	Low	Higher compared of tight coupling
Network Management and Ownership	Generally requires both networks to be owned by same operator	Permits independent deployment of both networks
Authentication	UMTS ciphering key used for WLAN encryption	Cellular access gateway provides authentication
Billing	UMTS accounting features reused	Billing mediator to provide common accounting
Real-Time Application Support	Yes	Not very suitable
Mobility Scheme	GPRS mobility management procedure used	Integration Mobile-IP functionality in WLAN gateway

The internetworking architecture of Mobile IP [24] considers WLANs and UMTS network as independent, which allows the easy deployment, but suffers from functions, real tome services and long handoff latency. The gateway approach [25] permits the two network independent operation which then gives facility of seamless roaming between the networks. Both networks are connects via virtual GPRS support node using a new logical node. The use of Mobile IP is not required in the gateway approach which has a loss during handoff comparatively lower packet. It is difficult to deploy emulator approach [24] when it requires ownership of the both two networks but due to low handoff latency yield make it much better suited for real-time applications well suited. Table 2 reviews and summarizes the tight and loose coupling internetworking strategies and their features.

5. NETORK SELECTION AND HANOVER DECISION

A handover decision from a UMTS interface to a WLAN interface is illustrated in Figure 7. Once a WLAN access network is discovered and its received signal ($\emptyset_0$)is acceptable, the MN will trigger the network selection process. If the selected access network technology is WLAN, the vertical handover is then initiated. If the connection (including the authentication and QoS reservation) is successfully setup, the UMTS interface switches to standby state and the handover is complete. Otherwise, the MN remains connected to the UMTS network.

While the MN is communicating via a WiFi interface. When the WiFi interface is about to be powered off, the MN initiates the network selection algorithm to determine a suitable target UMTS access network. If the MN notices new neighboring access nodes, the network selection will be triggered. No handover occurs if the serving access network grants the highest utility. Otherwise, the vertical handover to the selected access network will be performed. Finally, if the WLAN signal level drops below the adaptive handover threshold ($\emptyset_h$) without detecting the presence of a WLAN access node, the MN will handover to the UMTS to maintain the connectivity

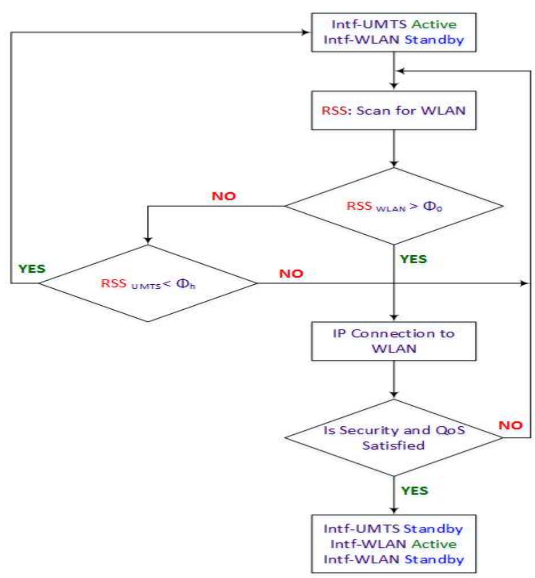

Figure 7: Handover from UMTS to WLAN

6. SIMULATION RESULTS AND ANALYSIS

In this section, the two proposed coupling architectures of UMTS/WLAN networks were simulated and an analysis was carried out for various Internet applications using OPNET Modeler 14.5. The overall performance of the both coupling schemes was broadly investigated with three major applications: file transfer protocol (ftp), hypertext transfer protocol (http) and video conference.

Journal of Theoretical and Applied Information Technology
20th September 2015. Vol.79. No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

The results found for each application are provided in the following three sections. Firstly, video application was discussed where loose coupling was found to provide better performance when considering overall QoS. Then ftp and http applications are discussed respectively.

6.1 Video Applications

The jitter for the video application for both coupling schemes is shown in Figure 8. Jitter, the variation of packet or cell inter-arrival delay, is another factor which affects delay, especially during a handoff.

In this work the jitter was computed, if two consecutive packets leave the source node with time stamps t_1 and t_2 and are played back at the destination node at time t_3 and t_4, then:

$$\text{Jitter} = (t_4 - t_3)-(t_2 - t_1) \qquad (1)$$

Negative jitter indicates that the time difference between the packet arrivals at the destination node was less than that at the source node. It is evident from the simulation results that the loose coupling was found to provide better performance overall with less jitter.

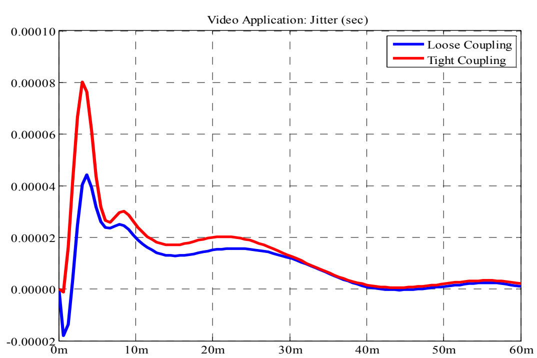

Figure 8: Jitter for Video Applications

Figure 9 shows the End-to-End Delay for video applications. The horizontal axis shows the increasing simulation time from left to right and this corresponds to an increase in traffic and the vertical axis shows the End-to-End delay value. The loose coupling was found to provide better performance overall with less delay. At the beginning of the simulation the End-to-End delay was smaller and as the traffic increases End-to-End delay becomes more noticeable.

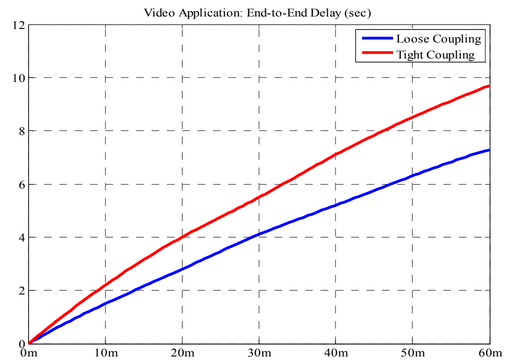

Figure 9: End-to-End Delay for Video Applications

6.2 FTP Applications

FTP applications were evaluated in terms of upload and download response times. The upload response time defined as the time elapsed between sending a file and receiving the response while the download response time defined as the time elapsed between sending a request and receiving the response.

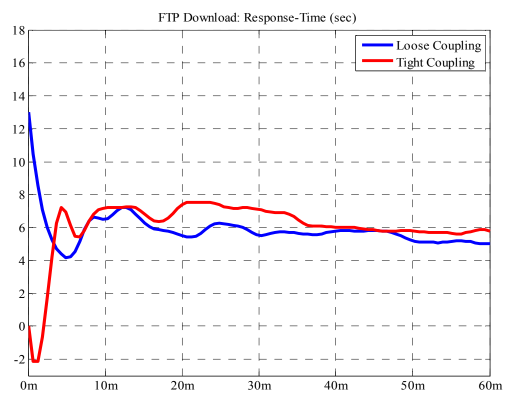

Figure 10: FTP Applications Download Response-Time

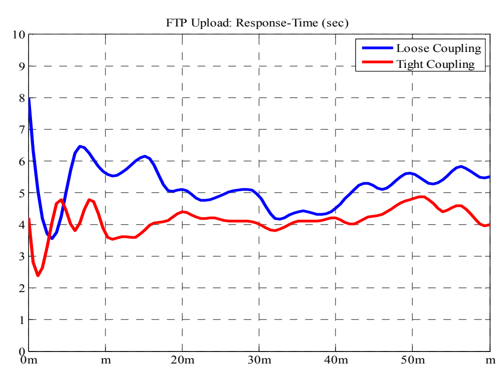

Figure 11: FTP Applications Upload Response-Time

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

FTP downloads and uploads response times illustrated in Figure 10 and Figure 11 respectively. The spikes appeared on the graph represent the time where the user sends the request to download the file from the ftp server. It is noticeable from the graphs that initially when there is less traffic the FTP response times to download and upload are low but as the simulation time passes more and more traffic is sent the response time increases. Our simulation results show that the loose coupling architecture is was found to have a lower FTP download response time, but it seen to take more time to get a response during upload when requesting to send a file compared to tight coupling architecture.

6.3 HTTP Applications

Figure 12 depicted our HTTP applications simulation results, where the horizontal axis shows the increasing simulation time from left to right and the vertical axis shows the response time of the HTTP page. It is clear that page response time is higher at the start of the simulation where the traffic is less there and the response is decreases as we move to the left where the traffic increases. The overall result shows that the tight coupling architecture is better than loose coupling due to a lower response time.

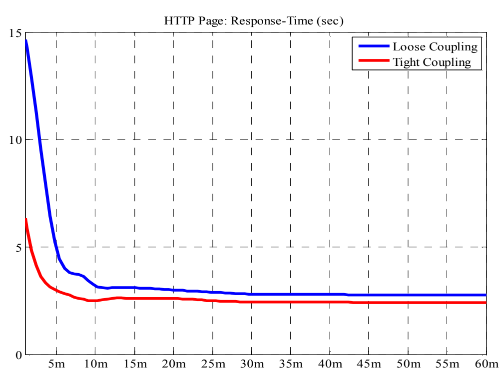

Figure 12: HTTP Applications Response-Time

7. CONCULSIONS

Since global roaming becomes an increasing trend, mobile users need to enjoy seamless mobility and ubiquitous access to services in an always best connected mode; as a result attention has been paid on mechanisms which are applicable in heterogeneous networks. In this context, the inter-system mobility management is an important and challenging technical issue to be solved. The underlying idea of this work was to analyse the UMTS/WLAN integration performance under various common applications. The work included the development of a model and simulation environment that could be used to gain results suitable for analysis. Specific attention was paid to design tight coupling and loose coupling architectures as this work direction taken was to identify an architecture that can provide better overall performance and flexible interworking.

In summary this work concluded that tight and loose coupling both have advantages depending on the Internet application examined. The reason for the inconsistency in results is found in the way the coupling technique affects traffic flow, handoff, authentication and mobility. To implement tight coupling changes to the current protocols used in WLAN are necessary. Loose coupling may be implemented more readily and thus providing simplicity and efficiency for 4G/WLAN integration.

ACKNOWLEDGEMENTS

This research was supported by Universiti Malaysia Pahang, through the Fundamental Research Grant Scheme (FRGS) funded by Ministry of Education (RDU 140129).

REFRENCES:

[1] L. Nithyanandan and I. Parthiban, Vertical Handoff in WLAN-WiMAX-LTE Heterogeneous Networks through Gateway Relocation, International J. of Wireless & Mobile Networks, vol. 4, no. 4, Aug 2012.
[2] Nadia Qasim and Muhammad Saleem Sheikh, Vertical Handover in Wireless Overlay Networks with Quality of Service Factors, Proc. of the World Congr. on Eng., vol. 2, July 2011.
[3] Sewon Jung, et al, Wireless LAN Handoff Module Implementation to OPNET Simulator and Handoff Performance Analysis, 6th International Conf. on Commun. (ICC), pp 151-156, June 2009.
[4] J. Strassner, Seamless service mobility: How autonomic networking and communications will shape the future of next generation services, in Proc. of the 1st international workshop on Seamless Service Mobility (SSMO), Marrakech, 2007
[5] M. Jaseemuddin, An architecture for integrating UMTS and 802.11 WLAN networks, in Proc. of 8th ISCC.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[6] Pramod Goyal, and S. K. Saxena, A Dynamic Decision Model For Vertical Handoffs Across Heterogeneous Wireless Networks, proceedings of World Academy of Science, Engineering & Technology Vol. 31 July 2008, pp 677-682.
[7] A. Dvir, R. Giladi, I. Kitroser & M. Segal,February ,Efficient decision handoff mechanism for heterogeneous network, International journal of Wireless and Mobile networks, Vol. 2, No.1. 2010.
[8] Mrs. Chandralekha & Dr. Prafulla Kumar Behera,November, Use of Adaptive Resonance Theory for Vertical Handoff Decision in Heterogeneous Wireless Environment, International Journal of Recent Trends in Engineering, Vol. 2, No. 3. 2009.
[9] E.Stevens-Navarro,Vincent W.S.Wong & Yuxia Lin, A Vertical Handoff Decision Algorithm for Heterogeneous Wireless Networks, In Proc. of Wireless Communications and Networking Conference, IEEE ; doi:10.1109/WCNC. 2007.590
[10] M. Buddhikot, G. Chandranmenon, S. Han, Y. Lee, S. Miller, Design and Implementation of a WLAN/CDMA2000 Internetworking Architecture, IEEE Communications Magazine, November 2003, pages 90-100.
[11] S. Tsao, C. Lin, VSGN: A Gateway Approach to Interconnect UMTS/WLAN Networks, The 13th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, PIMRC 2002, volume 1, pages 275-279.
[12] S. Tsao, C. Lin, Design and Evaluation of UMTS-WLAN Internetworking Strategies, Proceedings of IEEE Vehicular Technology Conference, VTC 2002, volume 2, pages 777-781.
[13] B. Hongyang, H. Chen, L. Jiang, Performance analysis of vertical handoff in a UMTS-WLAN integrated network, Proceedings of 14th IEEE conference on Personal, Indoor and Mobile Radio Communications, PIMRC, Sept. 2003, volume 1, pages 187-191.
[14]] P. Matusz, P. Machan, J. Wozniak, Analysis of profitability of inter-system handoffs between IEEE 802.11b and UMTS, Proceedings of 28th annual IEEE International conference on Local Computer Networks, LNC, October. 2003, pages 210-217
[15] I.F. Akyildiz, J. McNair, J.S.M. Ho, H. Uzunalioglu, and W. Wang, Mobility Management in Next Generation Wireless Systems, IEEE Proceedings Journal, Vol. 87, No. 8, pp. 1347-1385, August 1999.
[16] F. Di Cola, P.M.L. Chan, R.E. Sheriff and Y.F. Hu, Handover and QoS Support in Multi-Segment Broadband Networks, Proceedings of the 4th European Workshop on Mobile and Personal Satellite Communications, London, UK, 2000.
[17] H. Kaaranen et. al., UMTS networks: Architecture, Mobility and Services, Wiley 2001.
[18] 3GPP TS 25.331 V6.2.0, Radio Resource Control (RRC); Protocol Specification (Release 6), June 2004.
[19] Y.-B. Lin, Y.-R. Haung, Y.-K. Chen, and I. Chlamtac, Mobility Management: From GPRS to UMTS, Wireless Communications and Mobile Computing, 1(4): 339-360, 2001.
[20] 3GPP TS 24.008 V6.5.0, Mobile radio interface Layer 3 specification; Core network protocols; Stage 3 (Release 6), June 2004
[21] C. Perkins, ed., IP Mobility Support for IPv4, RFC 3344, Aug. 2002.
[22] D. Johnson, C. Perkins and J. Arkko, Mobility Support in IPv6, RFC 3775, June 2004.
[23] P. Reinbold and O. Bonaventure, IP Micro-Mobility Protocols, IEEE Communications Surveys, Third Quarter 2003, Volume 5, No. 1
[24] S. Tsao and C. Lin, Design and evaluation of UMTS-WLAN internetworking strategies, in Proceedings of IEEE Vehicular Technology Conf erence, Vol. 2, 2002, pp.777-781.
[25] S. Tsao and C. Lin, VSGN: a gateway approach to interconnect UMTS/WLAN networks, in Proceedings of the 13th IEEE .