Comparative Analysis of Vertical Handover in Integrated Networks

Prabhjot Kaur
Assistant Professor,
Bhai Gurdas Institute of Engineering & Technology, Sangrur

Maninder Singh
Assistant Professor,
Department of Computer Science,
Punjabi University, Patiala

ABSTRACT
Broadly accepted WLAN technology and the UMTS system are two most important wireless networks in the future. A lot of interests have been put in integrating these networks in order to get the benefit of both high data rate of WLAN and wide coverage area of cellular networks, and supporting end to end Quality of Service (QoS) is an unavoidable topic towards such a goal. Looking at the collective advantage of both heterogeneous networks is the inspiring feature of UMTS/WLAN integration. This paper proposes different solutions for UMTS/WLAN integration and vertical handover problems. The solution is based on an implementation of two coupling schemes that are later enhanced to support handover solutions. The work involves network simulation and comparative analysis for the proposed solutions, as well.

General Terms
Loose coupling, tight coupling, Mobile IP.

Keywords
WLAN, UMTS, coupling, mobile IP, EAP-AKA

1. INTRODUCTION
During the last few years there has been a fight amongst cellular operators in order to upgrade their existing infrastructure towards 3G systems, primarily the Universal Mobile Telecommunication System (UMTS), and at the same time, the popularity of Wireless Local Area Networks (WLANs) has risen many folds due to low deployment cost and high data transfer rates in the unlicensed frequency band between 2.4 GHz and 5 GHz. Capable to handle interference problems, these systems are considered to be ideal candidates for wireless hot-spots, where users can have the benefit of augmented bandwidth in limited geographical areas. The high data rates and penetration of WLANs encouraged operators and manufacturers to explore the option of combining them, as well as WLANs, with 3G systems in order to offer enhanced quality and a wider range of services to their users. These types of heterogeneous infrastructures are frequently referred to as beyond third generation (B3G) or fourth generation (4G) systems.

The present generation of mobile and wireless network is competent of providing continuous and endless streams of data and voice information. However, there are still limitations due to the absence in the integrity between different protocols that work these networks. The requirement and standards for B3G wireless networks require for transparent handover and seamless mobility between heterogeneous networks. Therefore, users will be able to roam into dissimilar networks without any break in the connection and can also access services provided by other networks as well.

The paper is organized as follows: Section II provides an overview of 3G/WLAN interworking; Section III presents the mobile IP based interworking; simulated network design is discussed in Section V and Section VI concludes the paper.

2. 3g-WLAN INTERWORKING
Several integration scenarios have been proposed in the literature in order to meet the WLAN/UMTS integration requirements. The focus of these scenarios is on four general requirements, i.e. service provisioning offers, billing and tracking issues, customer authentication, and handover issues. The scenario specifications perform the major role in identifying the level of integration. In this paper, the aim is to simulate the specifications of scenario 5 however other scenarios are certainly presented while studying a low level of coupling. Here, we explain briefly the likely coupling approaches implemented in this work.

2.1 Open Coupling
In an open coupling scheme there is no real integration between two different technologies i.e. two access networks are considered independent with only billing system shared between them. WLAN and UMTS use separate authentication procedures (i.e. SIM based authentication for 3G system and simply user name and password for WLAN) and a common database system is used to handle billing between both technologies.

2.2 Loose Coupling
In a loose coupling scheme both networks interconnect independently (they provide independent services) and utilize one common subscription. The use of a common authentication mechanism provides a link between Home Location Register (HLR) in the UMTS network and the authentication, authorisation and accounting (AAA) server in the WLAN network. In other words, loose coupling provides the subscribers with access to the 3G based services without making changes to the WLAN and UMTS protocols.

Actually it has no direct link to 3G network equipment. As a result the traffic from WLAN goes through the internet and does not pass through UMTS core network. The main element to provide mobility management in this architecture is mobile IP. On the other hand, there are several other variants to this coupling, which might include the user data traffic being routed to the UMTS Core Network. The data traffic is routed directly via an IP network which is an advantage of this method.

2.3 Tight Coupling

In a tight coupling scheme, WLAN is directly connected to UMTS core network in the same way as other UMTS radio access networks. Here WLAN Access Point (AP) is connected as a Radio Network Controller (RNC) to the UMTS Service GPRS Support Node (SGSN) to support the handover between WLAN and UMTS networks. In other words, tight coupling makes two different radio access technologies work together with a single core network.

In this context, WLAN can perform functions that are present in the 3G (RAN). The tight coupling integration scheme includes the reuse of UMTS AAA mechanisms, usage of common subscriber databases and billing systems, and increased security features. Tight coupling provides for the likelihood of continuous sessions as users move from one network to another, since the handover in this case is very much similar to an intra-UMTS handover, as the WLAN access point appears as another RNC to the SGSN node. A clear advantage of this method is that the UMTS mobility management schemes can be directly applied. The biggest disadvantage of this is that a bottleneck situation may arise at the SGSN as a result of the increased data traffic flow routed via the WLAN.

2.4 Very Tight Coupling

The very tight coupling scheme is very much similar to the tight coupling scheme with the addition that the WLAN access point is connected to the RNC.

3. MOBILE IP BASED OVERVIEW

Mobile IP is a network layer mobility management solution. The implementation of Mobile IP considers three main components: Mobile Node, Home Agent, and Foreign Agent.

The mobile node (MN) is a device such as a cell phone which has the network roaming capabilities. The home agent (HA) is a router present in the home network, which serves as an anchor point meant for communication with the mobile node; it tunnels packets starting from a device on the Internet, called a correspondent node (CN), to the roaming mobile node. The foreign agent (FA) is a router that may possibly work as the point of attachment for the mobile node when it roams into a foreign network, delivering packets to the mobile node from the home agent. The MN is assigned an address (called the care-of-address (CoA)) by the FA, which is the termination point of the tunnel towards the MN while it is in a foreign network.

The Mobile IP process has three main phases:

• Agent Discovery: FA and HA are discovered by the MN.

• Registration: The MN registers its existing location with the FA and HA.

• Tunneling: A reciprocal tunnel is set-up by the HA to the CoA in order to route packets to the MN.

When a mobile node moves to a foreign area, it first discovers the foreign agent. After that it is given a care of address CoA by that agent, which is delivered to the home agent. When a CN wants to talk to the MN, it contacts the home address. The packets are then intercepted by the HA and then tunneled to the FA which encapsulates the tunneled IP packet and deliver it to the MN. An optimization can be done if the CN is informed about the CoA of the MN. Then the packets can be directly sent to the FA without an interception from the HA.

4. SIMULATED NETWORK DESIGN

This section explains the simulation model and the applications used to calculate the performance of tight and loose coupling. In this paper Opnet Modeler 14.5 is used to simulate the hybrid UMTS/WLAN network. OPNET is an extremely flexible tool which provides drag and drop functionality for the communication devices (like interconnecting models and multiple protocols). However, Opnet doesn't offer some of the key components required in the network such as AAA, 3GAAA, HLR, Mobile IP under UMTS model and the EAP-AKA protocol. All of the additional components have been developed during this research. Two network scenarios were developed and the first included a tight coupling scheme and the second included a loose coupling scheme.

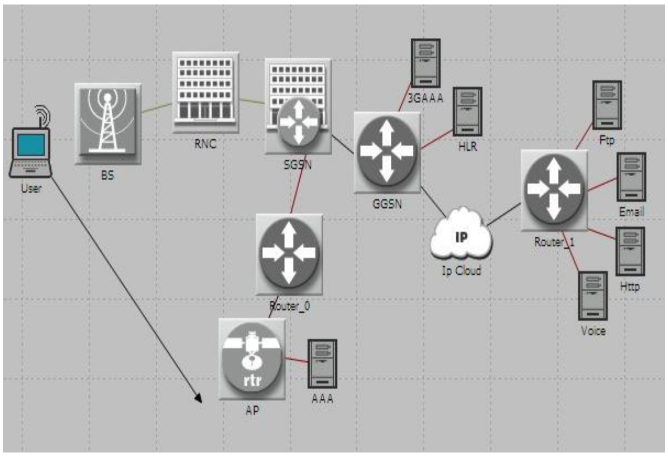

Fig 1: Tight Coupling

A 3G model was combined with 802.11g model to evaluate the network performance. In the case of the loose coupling scheme the AP was connected through the router to an IP cloud while in the tight coupling scheme a WLAN AP was connected through a router to a UMTS CN at the SGSN node. The service applications used in the simulation were added to the network design and the applications included ftp, http, and email. The network design for two scenarios is shown in Fig 1 and Fig 2.

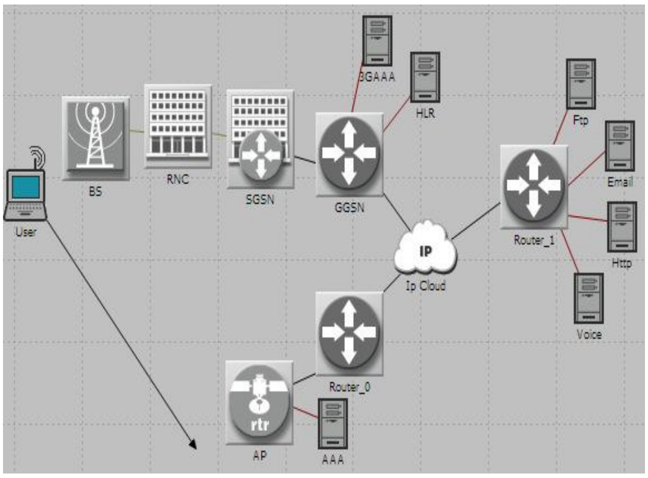

Fig 2: Loose Coupling

In this section the simulation results will be presented and discussed. The simulation results are related to ftp upload and download response time, ftp traffic sent, WLAN delay and throughput.

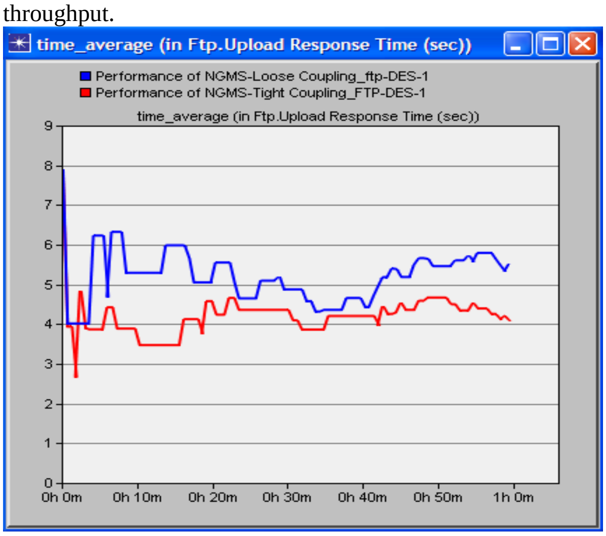

Fig 3: FTP response time to upload

Fig. 3 shows the FTP response time to upload a file and as the user load increases with time more traffic occurs and when requesting to send a file, the loose coupling scheme is seen to take more time to get a response as compared to tight coupling. Although in the loose coupling architecture the AAA server and packet switched services of UMTS are a part of an IP cloud which explains why response time for downloading a file is less and to upload a file is greater when compared to the tight coupling architecture in which the AAA server is part of the RNC.

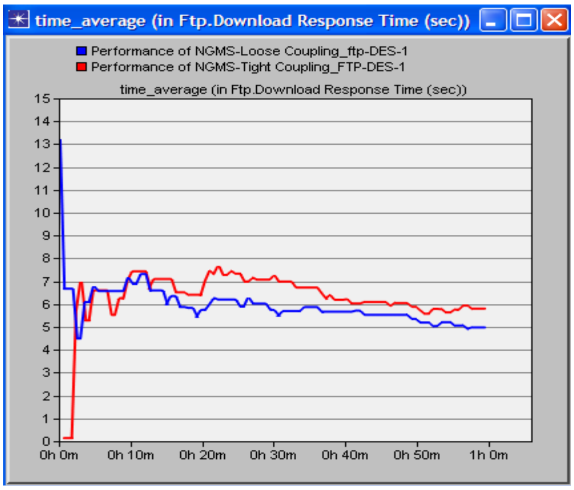

Fig 4: FTP response time to download

In Fig. 4, the graphs for the FTP response times are shown including the spike where the user sends the request to download the file from the ftp server. It is clear from the graph that initially when there is less traffic, the FTP download response time is low but as the simulation time passes more and more traffic is sent over the stream. The FTP transfer the request (which limits the networks resources), that is slower with more traffic and the response time increases. However if a comparison was made between the response times for the tight and loose coupling architectures then the loose coupling architecture was found to have a lower FTP download response time.

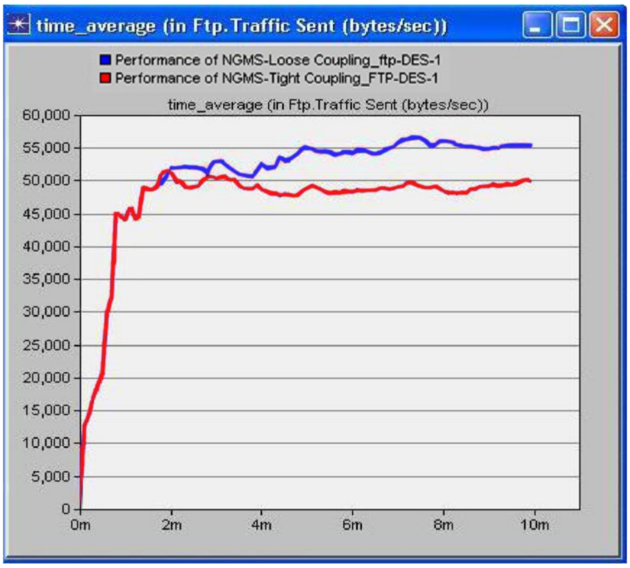

Fig 5: FTP traffic sent

Fig.5 shows the traffic sent for FTP and as the user load increases with time data sent increases, tight coupling scheme have to send more number of bytes as compare to loose coupling scheme to get the internet applications. As in loose coupling architecture AAA server and packet switched services of UMTS are a part of IP cloud so that is why response time for internet applications is less and data sent is greater as compare to open coupling architecture in which only AAA is common.

Graphs in fig 6 shows that the delays which are offered by the whole network to the WLAN devices to initialize the internet services. The delay increases with the number of users and loose coupling architecture has smaller delay as compare to the tight couple architecture.

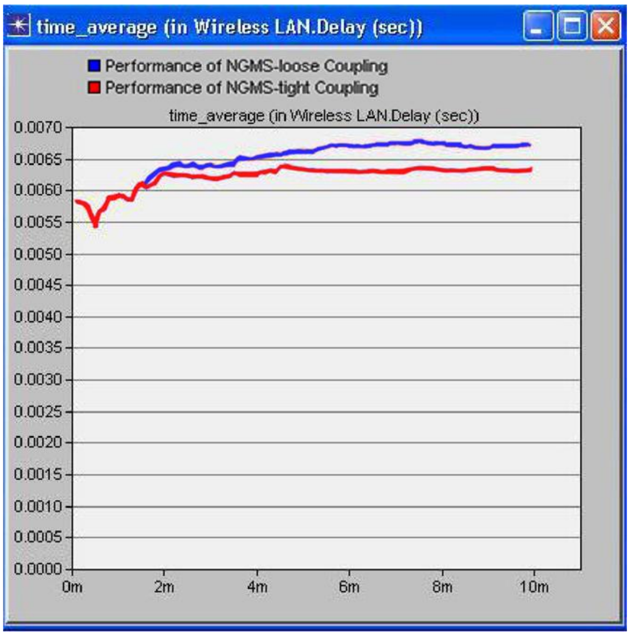

Fig 6: WLAN delay

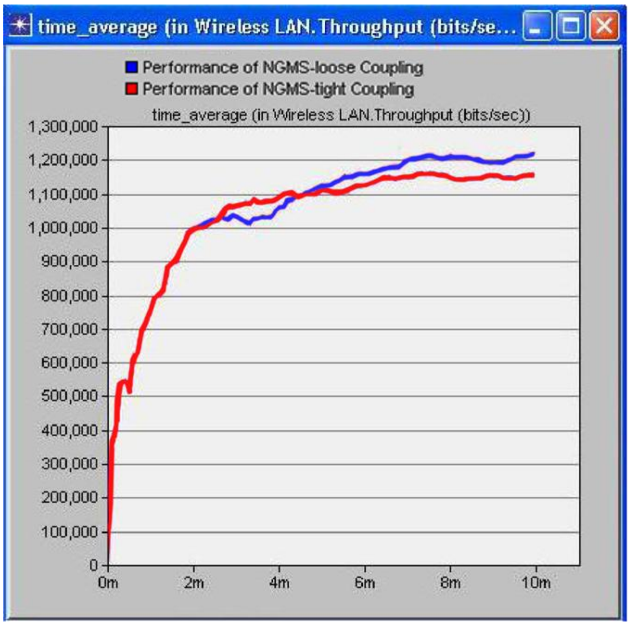

Fig 7: WLAN throughput

Graph in Fig.7 shows the throughput by the WLAN network which increases due to increase in number of users and tight coupling architecture have to send more amounts of data in order to access same services as in loose coupling architecture.

5. CONCLUSION

This paper highlights that tight and loose coupling have advantages depending on the application. Tight coupling offers a lower response time for ftp file uploads, on the other hand to download ftp files loose coupling provides a lower response time. Therefore, in order implement tight coupling some changes to the protocols used in WLAN are required. Loose coupling provides simplicity and efficiency and may be implemented more readily for 3G/WLAN integration. Future research work might contain how to minimize the ftp file upload response time for loose coupling.

6. REFERENCES

[1] Abu Sayed Chowdhury 2010 Next Generation Mobile Wireless Hybrid Network Interworking Architecture. RMIT Univesity, Australia.

[2] A. H. Zahran, B. Liang, and A. Saleh "Signal Threshold Adaptation for Vertical Handoff in Heterogeneous Wireless Networks", Mobile Networks and Applications, vol. 11, 625-640, 2006.

[3] Ali Al Shidhani, Victor C. M. Leung 2008 Reducing Re-authentication Delays During UMTS-WLAN Vertical Handovers. Technical Report. Department of Electrical and Computer Engineering The University of British Columbia Vancouver, BC, Canada.

[4] Apostolis K. Salkintzis, "Seamless Continuity Of Real-Time Video Across UMTS And WLAN Networks: Challenges And Performance Evaluation.", IEEE Wireless Communications, 2005.

[5] George Lampropoulos, Alexandros Kaloxylos, Nikos Passas, Lazaros Merakos 2007 Handover Management Architectures in Integrated WLAN/Cellular Networks.. Department of Informatics and Telecommunications University of Athens, Athens, Greece.

[6] J. Indulska, S. Balasubramaniam 2004 Context-aware Vertical Handovers between WLAN and 3G Networks. The University of Queensland Brisbane, QLD 4072, Australia.

[7] Li Ma, Fei Yu, Victor Leung 2003 A New Method to Support UMTS/WLAN Vertical Handover Using SCTP. Technical Report. Department of Electrical and Computer Engineering, The University of British Columbia Vancouver, BC, Canada.

[8] Marc Cardenete-Suriol, "VoIP performance in SIP-based vertical handovers between WLAN and GPRS/UMTS networks", IEEE Communications, 2007.

[9] Marwan Abu-Amara, Ashraf Mahmoud, Tarek Sheltami, Adel Al- Shahrani, Khalid Al-Otaibi, S.M.Rehman, and Taha Anwar 2007. Performance of UMTS/WLAN Integration at Hot-Spot Locations Using OPNET. In Proceedings of IEEEGCC.

[10]Michel Kadoch, Abderrahmane Benmimoune 2006. Vertical handover between UMTS and WLAN. Technical Report. Electrical Engineering Department, Ecole de Technologie Superieure (ETS), Canada.

[11] Pawel Matusz 2003. Analysis of Profitability of Inter-system Handovers between IEEE 802.11b and UMTS. In Proceedings of 28th Annual IEEE International Conference on Local Computer Networks.

[12] Zhang Peng, Ji Yang, Zhang Ping 2004. Network Selection in WLAN-3GPP Interworking System. Technical Report. Beijing University of Posts and Telecommunications Beijing, 100876, China.

[13] Zhiwei Yan, Huachun Zhou, Hongke Zhang,Sidong Zhang 2007. Speed-based Probability-driven Seamless Handover Scheme between WLAN and UMTS. In Proceedings of 4th International Conference on Mobile Ad-hoc and Sensor Networks..