Vertical Handover Scheme for Next Generation Mobile Networks (4G)

Hossen Altwelib, Majdi Ashibani and Fathi Ben Shatwan,
Higher Institute of Industry
mashibani@yahoo.co.uk
P. Box 841, Misurata, Libya

***Abstract*-With the rapid development of wireless communication technology, it is expected that the next generation of wireless networks "fourth Generation (4G)" is that will replace the third Generation (3G) networks within decades. The 4G mobile networks focus on seamlessly integrating the existing wireless technologies including 3G, GSM, wireless LAN, and Bluetooth into all-IP based heterogeneous network. While users roam throughout this heterogeneous environment, they should be automatically and transparently switched from one access technology to another (for example from IEEE 802 to 3G), depending upon the availability of resources and QoS requirements, without any user intervention. However, the migration of current wireless systems to 4G presents enormous challenges and new requirements like micro-mobility protocols, vertical handover support, adaptive applications and advanced QoS mechanisms. This paper addresses one of these challenges, that is vertical handover.**

I. INTRODUCTION

The research efforts involved in the development of the broadband wireless and mobile networks aim at creating an advanced telecommunications infrastructure, which can integrate diverse and incompatible wireless and mobile systems into a seamless radio and network infrastructure is a challenging task, particularly when the mobile host is to make the interoperation between the two technologies as seamless and as efficient as possible, both from the end-user's and from the operator's perspectives. Therefore, many issues have to be addressed before achieving this goal.

WLANs, originally targeted at enterprise and home networks, lack many of the capabilities which are essential in public environments. These capabilities include unified and universally accepted authentication, accounting and billing mechanisms; the integration of mobility mechanisms with QoS and application-level services; the support for heterogeneous network architectures through the implementation of roaming agreements. Conversely, although these characteristics are present by design in 3G networks, their implementation depends on specific wireless access architectures such as UMTS, and their extension to other wireless technologies such as IEEE 802.11 presents several compatibility issues.

One of these challenging issues is handover or handoff in mobile communication systems. Many analytical approaches have been proposed for handover analysis for these systems. The handover in mobile communication systems is classified into two types as illustrated in Fig. 1. The first type is horizontal handover; which is occurs when the mobile host moves between two base stations or access points having the same physical interface for example between two IEEE 802.11's Access Points. The second type is vertical handover; occurs when the mobile station moves between two systems with different air-interface, for example when the mobile host moves between 802.11 and Bluetooth, GPRS or UMTS systems.

The scope of this research is the vertical handover, which is typically imposes additional authorization procedures and other issues such as quality of service (QOS) provision which is becoming more complicated. For example, when a video-conference session on a broadband wireless network suddenly moved to a GSM network. Thus, a special end terminal architecture with media adaptation capabilities as well as end to end QoS negotiation and signalling mechanism (using Session Initiation Protocol SIP for example) will be required. This, comprises the vertical handover, which is investigated in this paper. In contrast to several approaches that investigate IP layer solutions, this paper, however proposes a data layer (layer 2) solution or mechanism to improve the vertical handover between mobile systems. The layer 2 solution, is based on a virtual MAC address assignment. Virtual Medium Access Control (MAC) is basically a layer 2 hardware unique identifier to the mobile host. Although IEEE 802.11 was chosen as an example of WLAN technology, the proposed scheme, in this paper is applicable also to other WLAN technologies.

The rest of this paper is organized as follows. Section 2, gives an overview on the evolution of mobile communication systems. In section 3, an integrated architecture for WLAN and 3G networks is proposed. Sections 4 however, describes our proposed integrated vertical handover scheme in details. Finally, section 5 presents some concluding remarks.

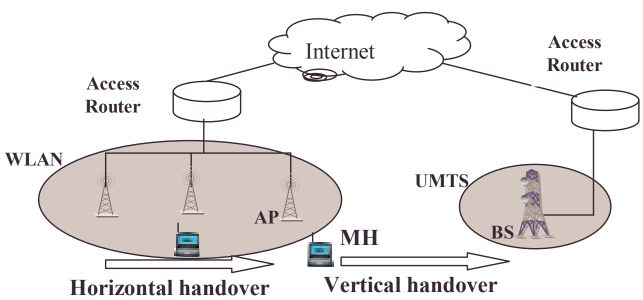

Figure 1: Horizontal and Vertical handover

II. EVOLUTION OF MOBILE COMMUNICATION

The evolution of mobile services have evolved from first generation to fourth generation are summarized in Table 1 [1,2,3]: First generation of mobile network (1G), was based on analog technique and was deployed in the 1980s. It built the basic structure of mobile communications and solved many fundamental problems e.g. cellular architecture, multiplexing frequency band, roaming across domain, non-interrupted communication in mobile circumstances, etc. Voice was the only service of 1G. Second generation of mobile network (2G), (GSM, cdmaOne, DAMPS) was based on digital signal processing techniques and regarded as a revolution from analog to digital technology, which has gained tremendous success during 1990s with GSM as the representative. The utilization of SIM (Subscriber Identity Module) cards and support capabilities for a large number of users were 2G's main contributions. 2.5G (GPRS, cdma2000 1x) extended the 2G with data service and packet switching methods, and it was regarded as 3G services for 2G networks. Under the same network infrastructure with 2G, 2.5G brought the Internet into mobile personal communications. This was a revolutionary concept leading to hybrid communications. Third generation of mobile networks (3G) (UMTS, cdma2000 1x EVDO, cdma2000 3x, EDGE, IMT-2000) is deploying a new system with new services instead of only providing higher data rate and broader bandwidth. Various multimedia data communications services are transmitted by convergent 3G networks. Fourth generation of mobile networks (4G) takes the following possible features; it supports interactive multimedia, voice, video, wireless high speed Internet access, high capacity, low cost per bit, Global mobility, service portability and scalable mobile networks.

TABLE 1 Mobile Communication Review

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Property	1G	2G	2.5G	3G	4G
Starting Time	1985	1992	1995	2002	2010-2012
Driven Technique	Analogue signal processing	Digital signal processing	Packet switching	Intelligent signal processing	Intelligent software Auto configuration
Standard	AMPS	GSM, TDMA	GPRS, HSCSD, EDGE	IMT-2000 (UMTS, CDMA2000)	FDM, MC-CDMA
Radio Frequency (HZ)	400M-800M	800M- 900M	1800M-1900M	2G	3G-5G
Bandwidth (bps)	2.4K-30K	906K-14.4K	171K-384K	2M-5M	10M-20M
Multi-address Technique	FDMA	TDMA, CDMA	TDMA, CDMA	CDMA	FDMA, TDMA, CDMA
Coverage Cellular	Large area	Medium area	Medium area	Small area	Mini area
Core Networks	Telecom networks	Telecom networks	Telecom networks	Telecom networks Some IP networks	All-IP networks
Service	Voice	Voice, SMS	Data service	Voice, data Some multimedia	multimedia

III. INTEGRATED ARCHITECTURE FOR WLAN AND 3G NETWORKS

ETSI (European telecommunication standard institute) has defined two approaches for interworking of WLAN and cellular network; tight-coupled and loose coupled schemes. The architecture of loose coupled and tight coupled network are illustrated in Fig 2. The main difference between tight coupling and loose coupling is whether the user's traffic is delivered through the core network of UMTS or not [5]. In a tight coupling interworking architecture, a WLAN is connected to an UMTS core network in the same manner as other UMTS radio access networks. The WLAN gateway implements all the UMTS protocols (authentication, mobility management, etc.) required in the UMTS radio access network. In this approach, UMTS and WLAN would use the same authentication, mobility, and billing infrastructures. The main advantage of this solution is that the mechanisms for mobility, QoS, and security in the UMTS core network can be reused directly over the WLAN. However, tightly coupled solutions will be highly specific to the UMTS technology and require extensive access interface standardization of WLANs beyond the existing standards. Moreover, the configuration and design of UMTS network elements, such as the serving General Packet Radio Service (GPRS) support node (SGSN) and gateway GPRS support node (GGSN), have to be modified to sustain the increased traffic from WLANs. In a loose coupling approach, the WLAN gateway does not have any direct connection to UMTS network elements. Instead, they are connected to the Internet. WLAN traffic would not go through the UMTS core network. Since each network operates independently, under loose coupling scheme, networks don't need to change their network architectures or protocol stacks. Therefore, loose-coupled network cannot support service continuity to other access network during handover, thus loose-coupled scheme has long handover latency and packet loss [6]. Therefore, in this paper, we adapt the tightly coupled approach as the objective of designing any UMTS/WLAN vertical handover scheme is to make handover as seamlessly and efficiently as possible. The proposed scheme is based on tightly coupled approach. Our proposed scheme uses virtual MAC address assignment to perform vertical handover.

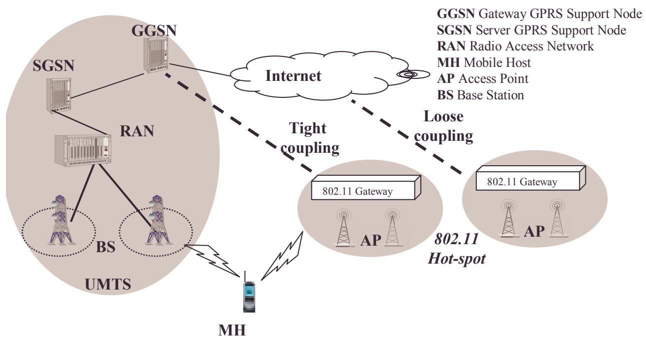

Figure 2: Integrated UMTS/WLAN systems

IV. ADAPTIVE INTEGRATED SCHEME

In this section the frame work of our proposed layer 2 adaptive integrated scheme is presented and discussed.

A. System Architecture

The proposed integrated scheme couples the WLAN and UMTS using Gateway hotspot support node (GHSN)[7]. Our scheme proposes that a GHSN should be added to connect WLAN's access point (AP) to GGSN as showing in Fig 3. The main functions of GHSN are summarized as following:

1. Radio Interfacing with UMTS and WLAN.
2. Creates Virtual MAC addresses based on IMSI (International Mobile Subscriber Identity) or random generator.
3. Forwards packets from/to AP and from/to GGSN.
4. Manages radio resources in WLAN and maps them onto the radio resources on UMTS and vice versa.

Our proposal requires that HSS (Home Subscriber Server) on the UMTS network to be modified in order to add some extra functionalities to support vertical handover. The HSS is the master data base on UMTS network contains all UMTS user related subscription information (i.e., user profile information including user identities, subscribed services, numbering, and addressing information) and tracking user location. The aim of our proposal is to minimize vertical handover latency. Therefore, vertical handover latency can be broken into the following components: movement detection time, MAC CoA configuration time and network registration time [8].

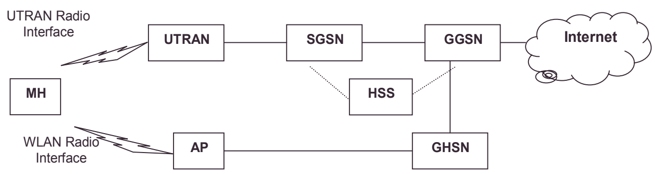

Figure 3 : UMTS/WLAN system architecture

B. Virtual MAC Address Assignment

MAC address is a layer 2 unique physical address stored inside the network interface card (NIC). MAC addresses are 6 byte addresses that are assigned by the IEEE. The first three bytes contain a manufacturer code and the last three bytes contain a unique station ID. The IEEE standard allows 2-bytes MAC addresses as well, but nowadays these two bytes are unused. In this paper we propose to use the 6 byte virtual MAC addresses, where the first three bytes are prefixed to FF-FF-FF (to identify the virtual MAC address). A unique virtual MAC address is assigned to each mobile device in UMTS network. Thus, there are different ways in which the mobile choose how to generate its virtual MAC address, it might be generated based on IMSI or random generator. More over, the mobile must perform also DAD (duplicate address detection) and do not begin to use this virtual MAC address until the DAD procedure been successfully executed. Also the virtual MAC address must be deleted and could be re-assigned to another mobile when the old mobile moves out of this area.

C. Handover Procedure

The vertical handover procedure proposed in this paper is described in the following steps and illustrated in Fig 3 and 4:

Step 1: MH sends a request message to the GHSN through the UTRAN, SGSN and GGSN, the request includes the IMSI of the user, LAI (location area identity).

Step 2: Based on IMSI the GHSN creates a virtual MAC address and inform the HSS by the assigned virtual MAC and IP addresses that assigned to MH.

STEP 3: The GHSN sends query message to HSS, the HSS checks if the subscriber has been registered or not and, after the DAD is completed, HSS stores this address and then sends a confirmation message to GHSN. At this point the registration process is completed.

Consider an example, a user has a laptop with both a UMTS and IEEE 802.11 radio interface. If the user was connected first to UMTS network. As the user moves toward a hot spot of 802.11 service, first the user must register in HSS as mentioned before. After that HSS will be able to locate the MH, and then send a message to GHSN contains the assigned virtual MAC address, the GHSN works as layer 2 switch. Then GHSN sends a frame to IEEE802.11 AP, AP fills the frame in address 1 and address 2 with MH MAC address and its own MAC address. For address 3 AP inserts the MAC address of GHSN.

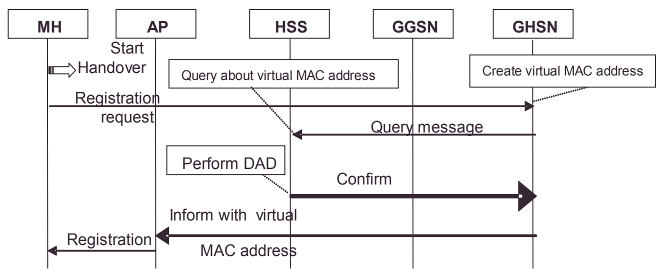

Figure: 4 Vertical Handover Scheme Procedure

V. CONCLUSION

This paper is a part of ongoing work that is related to the integration of third generation network with other wireless network technologies such as IEEE 802.11. This paper has proposed a vertical handover scheme between UMTS and IEEE802.11 networks. The proposed scheme requires a minor modifications to the UMTS architecture. A virtual MAC address assignment and a two integrated-architecture have been proposed to support such integration.

In this paper we have considered only the case of vertical handover from UMTS to WLAN. This paper also has showed how GHSN could be used as integrated component to support vertical handover between UMTS and WLAN. The approach does not require any major protocol and hardware modifications and can therfore be applied in current network without waiting for new protocol with built-in handover.

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