Abstract

Successive releases of 3GPP UMTS have incorporated increasingly higher levels of inter working between the WLAN technologies and the cellular mobile network using the IP Multimedia Subsystem (IMS). In UMTS Release 8 and beyond this inter working has been brought to the next level incorporating seamless service continuity which is the subject of many ongoing improvements and much research. In this paper we focus on proposing a novel solution to the issue of enhancing service continuity and seamless mobility between heterogeneous access networks connected to the IP Multimedia Subsystem. We have addressed the issue of seamless mobility between IMS enabled UMTS and WLAN networks by proposing changes in the signalling involved during vertical handoff thus leading to shorter handover delays when dual mode User equipment makes a switch over from one technology to another during an ongoing session. We shall discuss that by reducing the redundant signalling during the handover process but paying due consideration to the timing of certain indispensable signalling procedures such as security and authentication so that minimum delays are caused during the actual handover process itself thereby improving the seamlessness during an ongoing call without compromising the security and integrity of the signalling.

Keywords: IMS, Handoff, Wireless, Convergence and Access Networks

1. Introduction

The IP Multimedia Subsystem (IMS) is an architectural framework for delivering internet protocol (IP) multimedia to mobile users. It is a part of the vision for evolving Next Generation Networks.

The 3GPP has standardized the functions which shall be performed by the IMS and not the nodes [1]. IMS is an emerging reference architecture and is evolving through several standardisation groups, research labs, vendors and carriers with the basic purpose to provide horizontal functional layers which would allow efficient and cost effective service deployment on a common platform and to multiple access networks [2]. Like the internet the IMS is expected to evolve and grow over time. Network operators are expected to come up with their own customized solutions and as IMS continue to gain industry traction, interoperability, interworking and standards compliance between the network elements needs to be resolved.

Evolution in the telecommunications industry has traditionally followed a more or less linear path, with each generation of telecommunication networks focusing on higher speeds and greater efficiency as compared to the previous generation. In the recent past, however, technological progress has taken a new turn and the telecommunications industry is moving in a new direction which boasts not only of higher speeds, but there are also grand plans of convergence of different networks having a common IP backbone in a unified Next Generation Core Network with the IP Multimedia Subsystem (IMS) at its very heart [3].

According to [4], this convergence can be viewed from three angles

- Network Convergence
- Device Convergence
- User Service Convergence
The harmonised All IP network has the potential to provide a completely new telecom business model for both fixed and mobile network operators. Access independent IMS will be a key enabler for fixed/mobile convergence, reducing network installation and maintenance cost, and allowing new services to be rapidly developed and deployed to satisfy new market demands [3]. According to a study conducted by ABN AMRO on wireless LANs in 2001

“Public wireless LAN’s best prospect for growth comes from a symbiotic relationship with 2.5G/3G mobile telephone networks”[6]

Hence it is already established that some sort of interworking between WLANs and the cellular mobile networks is indispensable. We will now explore scenarios between WLAN interworking models and draw conclusion from different levels of interworking possible between the UMTS and WLAN.

2. Interworking Scenarios between WLAN and UMTS

Several interworking scenarios might exist between the WLAN and the cellular mobile network. These scenarios are broadly classified into one of three categories

- Tight coupling
- Loose Coupling
- Open coupling

Tight Coupling

Tight coupling is the only solution that brings a seamless handover between a wireless LAN and the mobile network offering the same level of security as UMTS. It requires standardization of a simplified Iu interface (Iu is the interface between the UMTS Radio Access network and the Core Network). The ETSI project called Broadband Radio Access Network (BRAN) is working on this specification for HiperLAN2. Tight coupling requires specific access network equipment and a wireless LAN terminal with an embedded Security Identity Module (SIM) card [6].

Loose Coupling

Loose coupling offers the same security benefits as tight coupling while requiring less standardization effort. The link between a wireless LAN and the mobile network is performed between the Authentication, Authorization and Accounting (AAA) server and the Home Location Register (HLR). The HLR stores the current location of mobile subscribers and the list of services to which they have access rights. The ETSI BRAN committee is also working on the specification this interface for HiperLAN2. Unlike tight coupling; loose coupling does not require specific access network equipment. The wireless LAN terminal could include a SIM card [6].

Open Coupling

Open coupling is a simple solution that does not require standardization. The link between the wireless LAN and the mobile network is performed at Customer Care and Billing System (CC&BS) levels. The AAA server sends information related to the usage of the wireless LAN network to the mobile network CC&BS. This solution does not employ the mobile network security mechanisms. All access equipment and wireless LAN interface cards are standard commercial products [6].

Tight and loose coupling offer security but require specific equipment meaning higher investment for operators and end users. New interfaces also need to be standardized. Open coupling requires no specific equipment, needs a limited investment and can be deployed today. To test the market, open coupling seems more adapted because of its readiness and its cost. In the long term the evolution of the network towards loose coupling is linked to the availability of terminals with wireless LAN capabilities and embedded SIM card [6].

2.1 Existing Levels of Interworking between WLAN and UMTS

UMTS has specified five levels of interworking between wireless LANs and cellular mobile networks. These various levels of interworking are associated with different levels of QoS, Billing and Charging, Security and Authentication and Roaming and Handoff. Release 6 has implemented only the first three interworking levels while the later interworking levels are expected to be implemented in future releases.

These interworking levels are defined in [7] as,

Common billing: The user will receive the bill for the services consumption on either platform in a coordinated way. However, it does not include any requirement to harmonize the tariff structure or level of services on the two platforms.

Common customer care: The user will not have to bother about which platform that might have caused his need to consult the customer care.

3GPP system based Access Control: The user faces control procedures (authentication and authorization) similar for WLAN as within the 3GPP domain.

3GPP system based Access Charging: This capability enables that the 3GPP charging mechanism can be reused for WLAN.

Access to 3GPP system PS based services from WLAN: The user is offered access to the same PS based services over WLAN as may be accessed via the 3GPP system.

Service continuity: services will survive the process of change of access network technology between WLAN and a 3GPP system.

Seamless service continuity: to provide seamless service continuity between the access technologies by minimizing aspects such as data loss and break time during the switch between access technologies.

Access to 3GPP system CS based Services with seamless mobility: to allow the operator to grant access to 3GPP system CS based services through the WLAN.

3. A New Interworking Approach for Seamless Mobility

We shall now present our solution to solving the vertical handoff problem and its possible integration in the IP Multimedia subsystem CN. In order to keep implementation as flexible as possible to match various interworking scenarios already deployed, we shall first present a high level description of our
approach. This will be followed by a more technical description of the call flows involved and a deeper appreciation of how such a solution might be technically implemented.

### 3.1 Proposed High level Solution

Our solution to the seamless handoff problem is based on the following propositions

1. As per [8] the handoff process must not compromise the security required for any of the access technologies hence authentication is an essential part of the handoff process and cannot be overlooked. We can view the authentication process as composed of two steps
   - Authentication with the IP multimedia subsystem core Network.
   - Authentication for the air interface for of access technology

   Our proposal is based on the two fold method of reducing the time required for both these stages.

2. During the handoff process authentication within the IMS core network can be made faster by simplifying the whole process and reducing the redundant signalling. If authentication has been made once before, we propose it should not be done again and the user does not have to necessarily re-register with the IMS thereby making the call flow as simple as possible.

   - We propose the introduction of a WLMSI (Wireless LAN Mobile Subscriber Identity) similar to the concept of IMSI and TMSI. This WLMSI will be a secure UE identity which will be generated and stored in the IMS Core Network (in the AAA or HSS server) at the time of registration of the UE into the IMS network regardless of the access mechanism used at the time of initial registration.

   - This WLMSI can be used at the time of handover from UMTS to the WLAN (possible in a manner the TMSI is used by the MSC) in order to authenticate the UE requesting the handover procedure and will serve to replace the cumbersome re-authentication procedure which is needed by the UE while accessing the system again via WLAN. Although in the WLAN mode the UE will have to pass through the security mechanisms of the WLAN in order to connect to the IMS, the process of re-registration and authentication within the IMS can be made simpler by such an arrangement and the only change required at the end of this authentication will be a simple change in the profile of the user from UMTS to WLAN mode in the concerned IMS node and a redirection message to be sent to the media stream to use the new access method for further data delivery.

   - This will significantly reduce the overhead time to setup the new data stream thereby reducing the duplication which might occur in data which is a problem in other solutions as is illustrated in [9]

3. Security and authentication mechanisms applied in UMTS are much more secure as compared to the general security precautions in a WLAN network although there are many schemes to make the WLAN more secure including the use of an IPsec tunnel for data transfer. Hence in the event there is a handover from WLAN to UMTS a re-authentication is necessary to bring the security profile to the UMTS standard which might again add to the handover time.

   - In order to overcome this, we propose that the standard UMTS method is also used in conjunction with authentication in the WLAN while performing the initial registration. In this way while initiating the handover procedure, it shall be easier to perform a faster transition from WLAN to UMTS or vice versa as the subscriber would already exist in the UMTS database which generally requires a more exhaustive authentication process as compared to WLAN. This is known as double authentication while registering.

   - Provided the UE has handover capability and both UMTS and WLAN networks are supported the UE might stay connected to both WLAN and UMTS networks and remain an active or “stand-by” subscriber in the respective databases.

   - WLAN does not have any paging like UMTS and the IP messaging overhead to keep the user connected might be considered negligible. UMTS on the other hand pages the subscribers even in the idle mode and the duration between these paging requests is controlled by the operator according to set policy. Keeping the user’s profile active in the UMTS VLR database as an active subscriber is a very small price to pay. As far as the SGSN and GGSN are concerned the user might stay in the “Attach State” although no PDP context is activated until the actual data transfer has to take place after the handover.

   - The constant paging of the UE by the UMTS network might be a drain on the UE battery and hence this issue needs to be addressed. One approach to solving this issue can be taken from the analogy that when a subscriber moves out of the GERAN coverage area the subscriber information remains in the VLR for a fixed time until the same user is picked up by another VLR or the information is purged.

   - However since the last roaming VLR of the subscriber is stored in the UMTS network, with the HLR containing the last VLR accessed and the VLR containing the subscriber records, locating the subscriber is much easier and much faster than a fresh LU and Attach procedure.

   - Similar approach can be adopted by 3GPP in future releases in establishing a separate node containing a
pool of subscribers which have performed the LU and the Attach procedure over GPRS but are nevertheless paged over a different channel at a lesser frequency than normal paging. Until then the user might have to seek a trade-off between shorter battery life and increased seamlessness in the Handover.

### 3.2 The Interworking Architecture

While choosing the interworking architecture for our proposed solution to be implemented we have kept in mind the following guideline.

"...3GPP does not standardize nodes but functions. This means that the IMS architecture is a collection of functions linked by standardized interfaces. Implementers are free to combine two functions into a single node e.g. into a single physical box. Similarly implementers can split a single function into two or more nodes." [1]

Although it is possible to combine multiple functions into a single node, this comes at a cost of increasingly complex machinery which requires better memory, storage and processor capability. While on the other hand the benefit of implementing multiple functions in a single node also means that there are lesser time delays as communication on internal interfaces is much faster than inter node communication over the network and should definitely lead to better efficiency and network performance as can be seen in the case of VLR and EIR which although were two separate functions, are most incorporated with the MSC as a single node by most vendors.

The IMS integration architecture which we have chosen for the implementation of this approach is given below.

![Interworking Architecture of a loosely coupled UMTS IMS network.](image1)

### 3.3 Cost Analysis of Proposed Approach

We now present an analysis of the cost benefits attained as a result of implementing our proposed approach. These analyses are for the user in the home network only but can also be adapted to the case of UE roaming in a foreign network with roaming agreement.

#### WLAN to UMTS Handover

The following figure gives the call flow for the 3GPP GPRS attach procedure. We shall compare this with the handover mechanism identified by 3GPP in [8] and identify the reduction in the handover time from WLAN to UMTS using our proposed approach of performing both handovers together.

![Handover procedure from I-WLAN to 3GPP Access.](image2)
We can see that the proposed approach of keeping the UE in the “attached” state prior to handover reduces the need for the first two stages in the handover. This translates to a reduction in the time required to perform the following actions:

- GPRS Attach Request and GPRS attach accept
- Authentication form the HLR
- Update Location and insert subscriber data.

4. Benefits of Using a Single IMS Node

The IMS registration session can be reduced to the call flow given below, thereby causing lesser network delays. However this is for the case where the P-CSCF and the S-CSCF are located in the same network. Where the user has roamed into another network the S-CSCF of the roamed network will come into play and hence network interfaces will be used. Nevertheless this is a useful approach for the normal case but customized solution depends on the network operator’s priorities and is left for the network optimization department of the individual operators.

5. Conclusions

Many approaches have been proposed in order to address the issue of vertical handoff and seamless mobility between WLAN and the UMTS however, no approach is perfect, they are not without their weaknesses and this is an area which is still seeing much ongoing research.

One of the notable schemes which promised reducing handoff time includes the One-pass GPRS authentication procedure [10] which although presented as a more efficient authentication mechanism, reduces the signalling and hence the time required for authentication which leads directly to handover delays.

The simulation results of traffic analysis for the proposed scheme using OPNet did produce expected results but the work could have been better executed if the UMTS configurations for RACH channel were available at the time of simulation.

6. References


[4] Ericsson white paper “Evolution towards converged services and Networks”


[7] 3GPP TR 22.934 Feasibility study on 3GPP system to WLAN interworking

[8] 3GPP TS23.327 Mobility between 3GPP-Wireless Local Area Network (WLAN) Interworking and 3GPP Systems (Release8)
