Facilitating 4G Convergence Using IMS

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ABSTRACT

In order to achieve the Fourth Generation of wireless communications (4G) goal of convergent and omnipresent communications and services, an efficient service delivery platform is necessary. The most promising services platform is the IP Multimedia Subsystem (IMS) as defined by the Third Generation Partnership Project. IMS provides a reliable and efficient architecture that supports multiple service categories while maintaining QoS and managing many aspects of the network such as authentication and accounting Utilizing IMS and enhancing its components to provide the abovementioned services can significantly help in building the envisioned ubiquitous 4G environment that consists of a standardized IMS core with extended capabilities. In this paper we describe how 4G convergence and mobility enhancement can be achieved via IMS. We also present a survey of current IMS convergence schemes for 4G.

Keywords

IP Multimedia Subsystem, IMS, 4G, Convergence, Mobility, Heterogeneous Networks

1. INTRODUCTION

In a remarkably short period of time mobile, cellular and smart phones have emerged from being rare, expensive and luxurious communication devices used by a small group of people, to become inexpensive and essential items in many peoples' daily lives. In most developed countries, Mobile Hosts (MHs) have outnumbered public switching telephone lines (PSTNs). In these countries the majority of adults and many children own personal MHs and some have even cancelled their land line subscriptions. The mobile fever has not been limited to developed countries; MH penetration is rapidly increasing in developing countries due to the lack of reliable PSTN infrastructures.

The appearance of future MHs may not change within the next few years, but what they will enable users to do is expected to improve and evolve drastically. The hi-tech market research company In-Stat [1] predicts that heterogeneous networking capabilities, high speed data rates, high quality multimedia services and user decision capabilities are just some of the expected future features and functionalities for MH users.

It is anticipated that the next generation – also known as the fourth generation (4G) – of MHs will integrate a substantially large number of diverse wireless technologies and exploit the advantages of each. Furthermore, users shall have the ability to balance between the Quality of Service (QoS) and amount of money they are willing to pay. MHs are expected to eventually replace landline phones, Personal Digital Assistants (PDAs), Global Positioning Systems (GPS), digital cameras, audio players, radios and even gaming. The future of wireless MHs is very exciting and promises to bring about many improvements into our daily lives.

Progressing from the previous three generations, 4G mobile systems promise significant improvements in terms of accessibility and interactive multimedia services. In order to best understand what the next generation of MHs have to offer and the research work that needs to be carried out, we briefly discuss the history and future of MHs. We then describe convergence and Interworking through IP, one of the main features of the next generation.

4G is expected to integrate a potentially large number of different wireless technologies in what could be considered as a huge step forward towards universal wireless access and omnipresent computing through seamless mobility [2] [3] [4]. This concept is known as convergence and is major part to the success of 4G and further evolution of mobile wireless communications. The need for convergence is based on the fact that, due to the vast number of network interfaces and the capabilities and shortcomes of each; no single networking technology is capable of carrying us into the next generation alone. A reliable convergent solution is crucial for the success of 4G and the evolution of wireless networks. Nonetheless, without a standard core framework, providing a truly scalable and successful 4G framework becomes impossible. The IP Multimedia Subsystem (IMS) is therefore used as the core framework on top of which 4G convergence can be implemented and supported.

The need for convergence is based on the fact that, due to the vast number of network interfaces and the capabilities and short comes of each; it no single networking technology is capable of carrying us into the next generation alone. Despite the rapid increase in WLAN hotspots, wireless Internet access remains limited to a small number of geographical areas because of their limited physical coverage. Satellites, alternatively, provide larger coverage areas but require a line of sight. Cellular networks on the other hand, despite their lower bandwidth, have a considerably wider coverage and do not require a line of sight and are therefore much more available. One of the revolutionary goals of fourth generation mobile systems includes a push towards universal wireless access and the ability to adapt to different radio transmissions and network interfaces [5]. A WLAN

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cell, for example, is overlaid within a cellular network cell and thus, the capacity of WLANs is combined with the coverage of wide area cellular networks. A transfer between two different network interfaces is known as vertical handoff. Without a standard core however, providing a truly scalable and successful 4G framework becomes impossible. IMS is therefore used as the core framework on top of which 4G convergence can be implemented and supported.

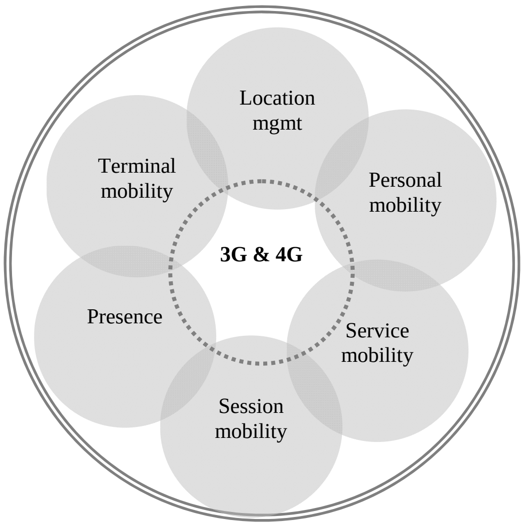

Figure 1: IMS integrates services such as video, voice and messaging with personal mobility, presence and terminal mobility

In this paper we show how IMS can be utilized to provide mobility management, vertical handoffs, presence, personal mobility, etc. to achieve 4G's goal of seamless mobility. We believe that a reliable standardized convergent solution is crucial for the success of 4G and the evolution of wireless networks and that IMS can bring by such a change.

We believe that IMS can provide a framework that accommodates current and future services in wired and wireless networks. IMS encompasses mobile, fixed, packet-switched, and circuit-switched communication systems. IMS integrates services such as video, voice and messaging with personal mobility, presence and terminal mobility. This IMS convergence of services and mobility is shown in Figure 1. IMS relies heavily on the Session Initiation Protocol (SIP) to manage and control sessions. SIP is an Internet Engineering Task Force (IETF) standard application layer protocol, which is used for initiating and managing an interactive user multimedia session. SIP can setup, modify or terminate data, video conferencing or Internet telephony sessions [6] [7]. IMS is a set of specifications that describes the Next Generation Networking (NGN) architecture for implementing IP based telephony and multimedia services [8]. IMS defines a complete architecture and framework that enables the convergence of voice, video, data and mobile network technology over an IP-based infrastructure. It fills the gap between the two most successful communication paradigms, cellular and Internet technology. IMS therefore paves the way for 4G. Utilizing IMS and enhancing its components to provide convergence can significantly help in building the envisioned 4G ubiquitous convergence environment that consists of a standardized IMS core with extended capabilities.

Paper Organization The rest of this paper is organized as follows: Section II describes the features of IMS that make it suitable for convergence. A discussion of IMS as an enabler of mobility and functionalities of IMS are discussed in Sections III and IV respectively. Survey of IMS convergence schemes are given in Section V. Section VI concludes the discussion.

2. IMS AS AN ENABLER OF 4G CONVERGENCE

IMS defines a complete architecture that enables the convergence of voice, video, data and mobile network technology services over an IP-based infrastructure. That being said, IMS provides the tools, to build services and ubiquitous networking, but does not provide the exact methodology of doing so. In order to utilize IMS for 4G the following benefits and features of IMS need to be realized:

- **Packet-switching** - IMS manages all the services through the packet-switched technology, which is more reliable and effective than its circuit-switched counterpart.
- **Multimedia QoS** - A 3G network provides "best effort" service, which means that the network provides no guarantees it will maintain a certain level of quality throughout the whole session. IMS guarantees that a certain QoS is provided during a session. This is achieved by interacting with core routers and utilizing Differentiated and Integrated Services.
- **Charging Mechanism** - IMS provides a flexible charging mechanism so that operators are able to charge appropriately for multimedia services. For example, operators can charge the video conferencing based upon the time used or any other reasonable measure rather than the bandwidth that the service consumes.
- **Integration of different services** - IMS provides a multitude of services to users and allows third parties to develop services and integrate them with existing solutions. This gives the operators the flexibility to offer a variety of services to further attract their customers.
- **Enhanced services** - IMS creates a service environment where any service can access any aspect of the session. This allows service providers to create far richer services than in an environment where all the services are independent of one another.
- **Interworking with legacy networks** - IMS contains modules and gateways that provide interworking with legacy telecommunications systems.
- **Increased communication scope** - IMS runs on an all-IP network which means that integrating with devices such as laptops connected to the Internet using any videoconferencing software for instance, becomes trivial. This significantly increases the number of people IMS subscribers are able to communicate with via all media types.

With all of the abovementioned features, it is not surprising that IMS is a significantly complex framework. The added value IMS could bring to 4G networks pays for this extra complexity.

Different MHs connect to a heterogeneity of different networks (3G, WiFi, WiMax, etc.) and domains. Each domain encompasses separate subscriber and service information for each MH. There is no joint database to manage information across all of these networks. As a result, these networks are for the most part independent of one another in many aspects and convergence is necessary. Convergence cannot be achieved reliably in a distributed manner. To realize convergence IMS must include a centralized entity that can control profiles, sessions, features and services across all devices and access technologies. The 3GPP releases describe IMS as a framework that does these exact tasks for IP Networks. IMS defines a core network which provides service negotiation and profile management across multiple MHs and heterogeneous networks. Consequently, an IP based IMS core would provide a unified application experience across all IP networks and IP enabled MHs. IMS provides interworking specifications [9] between heterogeneous network interfaces. Although these specifications are more of guidelines rather than actual implementations, they pave the way for a fully converged future.

With the suitable application support, this can result in a converged environment where a single MH can seamlessly roam across multiple networks. Furthermore, a user can access the same information and services though a multitude of different MHs. An incoming call can be routed to all devices or to specific devices in an order specified by the user. All of these devices and applications are part of a truly converged solution. This convergence thus leads to enhancing mobility and presence. IMS can thus be used to provide Personal, Terminal Service and Session Motilities. The next section explains how such enhanced mobility can be achieved using IMS.

3. IMS AS AN ENHANCER OF MOBILITY

In order to provide seamless mobility in future generation wireless networks, it is necessary to support personal, terminal, service and session mobility.

3.1 Personal Mobility

Personal Mobility (Figure 2) refers to the user's ability to access personalized mobility services that they are subscribed to from anywhere, at anytime and using any terminal.

An IMS SIP Registrar and Location Services Server keep track of all the possible terminals associated with a user, and the permanent and temporary addresses of each of those terminals, at any given time. This gives IMS natural personal mobility support. Users can use a single personal identifier in all occasions, regardless of the terminal used or network locations. Any incoming messages from a Corresponding Host (CH) will be redirected to the appropriate active terminal. In IMS there is also a deterministic way to identify users. An IMS user is allocated with one or more Public User Identities. The home operator is responsible for allocating these Public User Identities to each IMS subscriber.

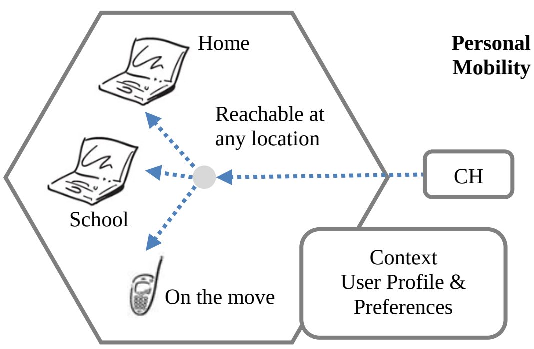

Figure 2: Personal mobility

3.2 Terminal Mobility

Terminal Mobility (Figure 3) refers to the user's ability to use their mobile device to move across heterogeneous wireless networks without getting disconnected and while having continuous access to the same set of subscribed services.

Terminal Mobility too can be provided in SIP as well as IMS through the use of the SIP Registrar and Redirect Server. As the terminal moves across heterogeneous networks new temporary identifiers (IP addresses) are assigned to the terminal. These are updated with the SIP Registrar by using the REGISTER method. The current location of the device is always up-to-date so that messages can be redirected successfully, in a time-efficient manner. This feature also helps in providing presence and location management.

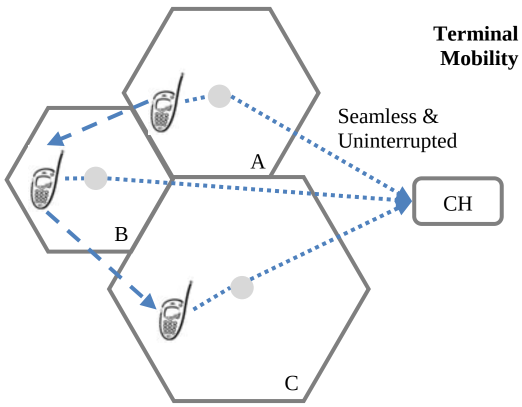

Figure 3: Terminal Mobility

3.3 Service Mobility

Service Mobility (Figure 4) refers to the network's ability to provide personalized services to the user regardless of their location. Hence, users are capable of transparently accessing their personalized services from any terminal with the same profile while on the move.

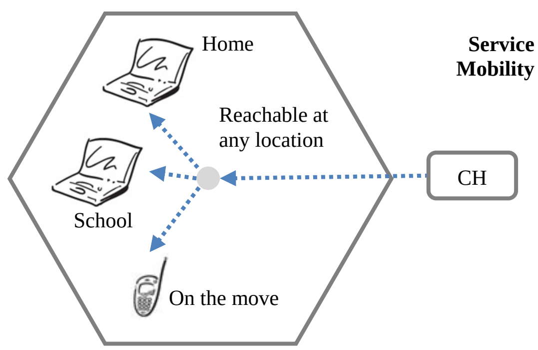

Figure 4: Service Mobility

Service continuity is essential whether the user is at a home or foreign network. Service mobility can also provide QoS guarantees as well as Authentication, Authorization, and Accounting (AAA). The user can connect to an IMS network using various methods, all of which are using the standard Internet Protocol. IMS terminals can register with an IMS network, even when they're roaming in a foreign network. By connecting to the IMS network from any location, service mobility is achieved.

3.4 Session Mobility

Session Mobility (Figure 5) refers to the user's ability to maintain an active session while moving across networks or switching between terminals. IMS can implement session mobility through the use of the A SIP re-INVITE method.

3.5 Terminal, Personal, Session and Service Mobility and 4G

Combining Personal, Terminal, Session and Service Mobility is the ultimate goal of 4G: here personal mobility would be about end-user call preference management, which would not impact active sessions. Terminal mobility on the other hand would be more technical handoff management for active sessions that would potentially be seamless and transparent. Session mobility would be active call or multimedia session transfer between terminals, which would be taken into account at application layer in session management logic. Service mobility allows users to maintain access to their services wherever they roam.

To better understand these four dimensions of mobility consider the following scenario. Jane runs a small business that requires a great deal of travelling around to meet clients, suppliers and distributors. On the move, she uses her smart mobile 4G device to place phone calls, check her email and even place video conferences from time to time. On a light day, she may watch her favourite TV program via IPTV. Jane's smart device supports all four dimensions of mobility. As Jane moves into the coverage of different wireless networks such as WiMax, 3G and WiFi, the smart device seamlessly hands off without any disruption to the ongoing session(s). By doing so, full support for terminal mobility is ensured. When Jane arrives at her office she transfer her current sessions from her smart phone onto her laptop through the session mobility support provided. The sessions adapt to the change in resolution, sound and caching mechanism by changing streaming characteristics. Jane is also able to maintain access to her services even while moving or changing devices and network service providers. This is made feasible through a service mobility protocol and makes Jane available to her customers wherever she goes. Finally, through personal mobility, Jane is able to provide her user preferences and optimize her usage for cost or quality. A true ubiquitous environment can only be provided by combining terminal, personal, service, and session motilities.

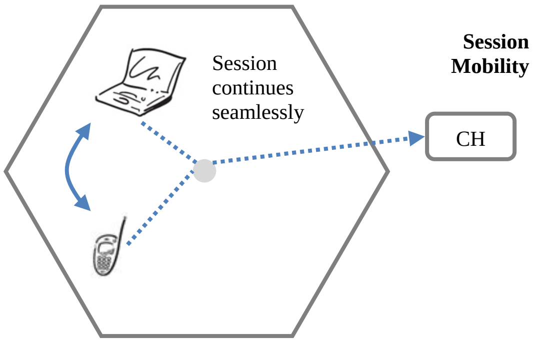

Figure 5: Session Mobility

4 IMS FUNCTIONALITY AT EACH LAYER

In this section, we describe the way in which IMS can be utilized at the transport, session and application layers. Understanding how IMS operates at each layer is a huge step forward towards building a truly omnipresent, convergent environment.

4.1 Transport Layer (Media)

The transport layer provides end-to-end communication. In IMS this includes initiating and terminating SIP sessions and providing carrier specific services such as converting analogue formats to IP packets using the Real time Transport Protocol (RTP). The transport layer provides media gateways and extensions for converting VoIP streams to the analogue PSTN format. The media server offers various media related services including voice and video conferencing, streaming announcements, speech recognition, speech synthesis, and many more.

The media server shares its resources with all applications. As a result, every application that involves broadcasting announcements for instance can make use of a shared media server. These applications may include interactive services, voice mail, services, as well as any media related service. Multiple media servers can co-exist cooperate and share resources.

4.2 Application Layer (Session Control)

The session control layer includes the Call Session Control Function (CSCF), which provides the registration of the endpoints and routing of the SIP signalling messages to the appropriate application server. The CSCF communicates with the transport layer to guarantee Quality of Service across all services. This session layer also includes the Home Subscriber Server (HSS) database that maintains the unique service profile for each end user. The end user's service profile stores all of the user service information and preferences in a central location. This includes an end user's current registration information (such as location and current IP address), roaming information, multimedia services (such as call forwarding information), instant messaging service information (such as buddies list and who's online), answering options (such as voice mail greetings), etc. By unifying this information, applications can share and exchange information to form centralized personal directories, enable features like presence and context awareness, and blend together services. This structured framework also makes the administration of user data significantly simpler and insures network consistency amongst all service subscribers. Besides these modules and components, the session layer includes the Media Gateway Control Function (MGCF), which integrates the SIP signalling with the signalling used by the media gateway. The MGCF manages the allocation of sessions between multiple media gateways.

4.3 Application Layer (Application Servers)

The application layer also includes the application servers (AS), which present the end user with suitable services. The IMS architecture and SIP signalling is extensible and flexible enough to support a variety of application servers. For example, Application servers can be used to provide media functionalities or maybe even provide Interworking between different wireless technologies!

Application servers can run SIP based applications. These application servers can interact with endpoints or IMS devices to offer services such as Instant Messaging, Push-to-Talk, presence-enabled or context-aware services. By putting into operation these SIP based services in the IMS architecture it is possible to create new blended and intelligent communication services. One example of such an intelligent service is the ability to provide customized services and seamless communications to users as they roam about. A more specific example of a blended service is instant messaging, where a list of friends, their presence (whether they are online or offline) and location are displayed.

5 IMS CONVERGENCE AND INTERWORKING SCHEMES

In this section the Interworking requirements proposed by 3GPP are explained followed by a description of currently proposed solutions.

5.1 Requirements

In order to design a successful and feasible Interworking system it is necessary to use the framework and scenarios proposed by 3GPP TR 23.234 [9] for guidance. Under this framework, six common interworking scenarios have been identified. The first scenario, which is the simplest, provides only a common bill and customer care to the subscriber but no real interworking between WLAN and IMS core. The second scenario provides the IMS subscriber with a basic IP network connection through a WLAN and includes no other services. The third level extends the IMS services to the WLAN, although it is an implementation matter as to whether all services or just a subset of them are provided. This scenario lacks service continuity, so the user has to re-establish the session in the new access network. The fourth level introduces service continuity while the fifth level provides seamless continuity. The sixth level has only recently been proposed and it provides access to 3GPP CS based services as well as IP services. A summary of the six levels is shown in Table 1.

Coupling:	Weak			Strong		
Level:	1	2	3	4	5	6
Common billing and common customer care	•	•	•	•	•	•
3GPP-Based access control and access charging		•	•	•	•	•
Access to 3GPP PS services without continuity			•	•	•	•
Access to 3GPP PS services with continuity				•	•	•
Access to 3GPP PS seamless services					•	•
Access to 3GPP CS based services						•

Table 1: Interworking scenarios based on Table 3 of TR 23.234 [9]

Scenario 1: Common Billing and Customer Care. In this scenario the objective is to have shared billing between the IMS and WLAN. Since the WLAN uses a SIP server and WLAN AS to route the SIP messages through the home network the IMS billing modules monitor both, users within the 3GPP network and users within the WLAN.

Scenario 2: 3GPP system-based access control and charging. The objective of this scenario is to provide unified authentication and authorization. The key factor behind achieving system based access control and charging is being able to access the HSS, whether in a direct or indirect manner. A user connected to a WLAN can be authenticated and authorized through the 3GPP system by routing REGISTER messages through the SIP server which in turn forwards it to the WLAN AS. From there on the messages follow the traditional IMS authentication route with the main difference being the lack of P-CSCF involvement and the interaction of the WLAN AS instead.

Scenario 3: Access to 3GPP system IMS-based services. In this scenario our objective was to setup, maintain and terminate an IMS session from within the WLAN. It is necessary to satisfy the requirements in Scenarios one and two and further have the ability to exchange SIP messages through the interrogating nodes to send and receive session requests and exchange messages until a session is complete.

Scenario 4: Service Continuity. In this scenario our objective was to setup, maintain and terminate an IMS session from within the WLAN as well as handoff from one network to another. It is necessary to satisfy the requirements in Scenarios one, two and three but further have the ability to vertically handoff between the WLAN and IMS 3G. Handoff delay is not a concern in this case.

Scenario 5: Seamless Services. The objective of this scenario is to provide continuity. As the users roam from the coverage of one network interface to the next they should not notice or feel the transition. The handoff ought to be seamless with low delay and latency.

Scenario 6: Backward compatibility with Legacy systems. The objective of this scenario is to support legacy circuit switched systems. By doing so, the system is backward compatible and capable of support old as well as newer technologies.

5.2 Schemes

In this section we compare multiple IMS-related schemes. Table 2 compares these schemes based on their feasibility (whether it requires changes to current architecture), full potential (scenarios proposed by 3GPP TR 23.234 [9] does it tackle) and security.

Munasinghe et al. [10] present an interworking model for WLAN and 3G cellular networks with the IMS acting as a signalling mediator. The authors claim that the most significant benefit of this approach is its ability to negotiate and manage real-time sessions. The data originating from the WLAN is routed via a Serving GPRS Support Node (SGSN) emulator to the UMTS Gateway GPRS Support Node (GGSN). It essentially emulates the WLAN as another SGSN belonging to the same UMTS network. Unfortunately, the solution requires significant functionality needs to be added to the SGSN, effectively complicating the architecture. The authors do not perform any simulation or performance analysis which raises the question of whether the development of such an emulator is feasible or practical. Furthermore, the proposed mobility manager is incapable of handling seamless data routing or QoS when high data volumes originate from the WLAN.

Prasithsangaree et al. [11] address the limitations of existing standard authentication protocols for use in WLAN operator networks in a loosely-coupled 3G-WLAN architecture. They propose a new authentication mechanism, LDSA, which requires no direct connection between an independent WLAN and the 3G operator network. While this eliminates the requirement of trust management, the scheme increases the amount of energy consumed and messages exchanged. Furthermore, it does not address the issue of initiating, maintaining and terminating a session. IMS is addressed as part of the solution.

Noël Crespi et al. [12] analyse the main architectural requirements to enable a Multi-access to the UMTS IMS. Their work explores the requirements and constraints for a heterogeneous access to the IMS and proposes architectural principles for its evolution in future releases of UMTS. In particular, the authors suggest the introduction of a new functional entity in the WLAN access networks, the WLAN Access SIP Proxy, in charge of billing, access to services and QoS control. However, this architectural style poses a significant amount of security threats and leaves the whole system vulnerable to attacks. By communicating directly with the CSCF and storing authorization and authentication information in the WLAN network, the threats described in RFC 3261 [13] are possible. Furthermore these features require major changes to the WLAN networks.

Wei-Kuo Chiang et al. [14] propose a network-initiated triggering mechanism to facilitate terminal mobility with the session initiation protocol (SIP) in 3GPP Voice over WLAN (VoWLAN). The architectural design seems very promising and, if integrated with the latest IMS release, it can provide a promising solution to the issue of 3GPP/WLAN mobility and Interworking. Nonetheless, some architectural properties are slightly vague and need to be explained more thoroughly.

Fermin Galan Marquez et al. [15] describe the main characteristics of SIP and WLAN and the interworking aspects of these two technologies through IMS. They offer a discussion analyzing the problems identified in providing this interworking. The paper covers the interworking issue from a very abstract point of view; it does not go into any of the implementation details and borrows most of its content from the 3GPP TR 22.934 [16].

Hasswa et al. [17] propose an interworking model for extending IMS to WLANs. The model takes into account the interaction of WLAN SIP servers with the IMS Call Session Control Functions and ASs. It also takes into account the IMS interaction with core routers to provide authentication, authorization, policies and QoS. The premise of this work is based on the fact that IMS is already backward compatible with legacy systems. If the IMS ASs are capable of providing backward compatibility with legacy systems, they could, in effect, be utilized to provide forward compatibility with WLANs to provide WLAN-3G interworking.

In the latest 3GPP releases [18] [19], a document specifying the system description for interworking between 3GPP systems and Wireless Local Area Networks (WLANs) was released. The intent of 3GPP–WLAN Interworking is to extend 3GPP services and functionality to the WLAN access environment. The 3GPP–WLAN Interworking System provides bearer services allowing a 3GPP subscriber to use a WLAN to access 3GPP packet switched based services. The document provides guidelines and advice on how such interworking should be approached. However, a clear and thorough architecture is not provided. This document provides the basis that should be followed in designing a feasible 3GPP-WLAN interworking architecture.

6 DISCUSSION AND CONCLUSION

In order to achieve the 4G goal of omnipresent communications and services, an efficient service delivery platform is necessary. The most promising services platform is the IP Multimedia Subsystem as defined by the Third Generation Partnership Project. The IMS standard provides a reliable and efficient architecture that supports multiple service categories while maintaining QoS and managing many aspects of the network such as authentication and accounting Utilizing IMS and enhancing it’s components to provide the abovementioned services can significantly help in building the envisioned ubiquitous environment that consists of a standardized IMS core with extended capabilities. Some open research issues are:

- **IMS Interworking** - IMS is currently capable of interacting with 3G networks only. Extending IMS beyond 3G to Wireless Local Area Networks (WLANs) such as 802.11x and WiMax (802.16) is a crucial step towards the evolution of a seamless universal wireless network. Some of the aspects that need to be analyzed in this area include the interaction of WLAN and WiFi or WiMax SIP servers with the IMS Call Session Control Functions. Another issue is related to the IMS interaction with core routers to provide policies and QoS. Charging is also an issue: Should all networks use a single charging module? How is AAA managed? Personal mobility needs to be studied in depth too: What happens if a user roams into a different network? Can we maintain their current session? And if possible, how is this achieved? These are only some of the many issues that need to be studied before a truly ubiquitous and seamless environment could be designed.

- **IMS User Anonymization** - Anonymization of the user is a very crucial topic since it requires a compromise between functionality and user privacy. With IMS users have a universal sign on feature where they can register with any network and notify their home network of their location. However, some people may be concerned about the privacy issues and may not want to be continuously tracked as they move about. Designing solutions to ensure user privacy is an open research topic.

- **IMS Service Standardization** – The IMS Core serves as a docking station for any kind of application server, as long as it provides a minimum standardized (and extended) SIP control interface. This means that existing telecom service platforms, such as OSA/Parlay gateways, and SIP servlet servers, can be reused and potentially combined, as long as they provide an IMS/SIP adapter interface. The IMS doesn’t yet focus on the standardized implementation of services.

- **4G Vertical Mobility** – In addition to Interworking, the ability of a MH to vertically handoff and thus access services from different networks is an imperative functionality that needs to be considered. Seamless handoff is also a fundamental concern in any system with mobility. It is important to ensure a minimal level of QoS is always met in order to avoid disconnection or disruption of an active connection. Seamless handoff can be achieved by reducing the handoff latency. A system with low handoff latency and close to zero packet loss can allow active connections to migrate between heterogeneous networks and make use of varying network conditions. Although numerous solutions have been proposed for seamless vertical handoff, most of these are stand alone solutions that cannot interact with current standards such as IMS. Integrating mobility solutions with the IMS framework is an unresolved research issue.

- **4G User Preferences** – The fourth generation of mobile wireless networks aims at allowing users to specify their personal preferences (e.g. whether they care more about the quality of service or usage cost, etc.). Although some work has been carried out in the area of proactive handoff, these solutions usually focus on satisfying user needs only and ignore other networking requirements leading to unexpected results and poor system performance. Proactive handoff along with adaptation and context-awareness should result in higher user satisfaction levels.

- **4G Context Awareness** – Context-awareness remains one of the least utilized features in universal networking schemes, although it is one of the most powerful. Designing the ultimate context aware universal connectivity scheme remains unresolved.

Scheme	**Munasinghe et al.** [10]	**Prasithsangaree et al.** [11]	**Noël Crespi et al.** [12]	**Wei-Kuo Chiang et al.** [14]	**Fermin Marquez et al.** [15]	**Ahmed Hasswa et al.** [17]
New modules added	SGSN Emulator	LDSA	WLAN Access SIP Proxy	None	None	WLAN SIP Server and WLAN AS
Requires change to core network	Yes, additions to SGSN	No	Yes, changes to WLAN core	No	Unknown	No
Interworks with	WLAN	WLAN	WLAN	WLAN	WLAN	WLAN
Interworking level [9]	5	2	3	3	5	5
Requires communication between Operators	Yes	No	Yes	No	Unknown	No
Security	Not discussed but some limitations due to SGSN modifications	Secure	Major risk due to direct communication with CSCFs	Secure	Not addressed	Secure
Limitations	Mobility manager is incapable of handling seamless data routing or QoS when high data volumes originate from the WLAN	Does not address the issue of initiating, maintaining and terminating a session	Features require major changes to the WLAN networks	Some architectural properties are slightly vague and need to be explained more thoroughly	Covers the interworking issue from a very abstract point of view; it does not go into any implementation details	Simulation or implementation necessary to test proposed scheme.

Table 2: Evaluation of IMS-based Interworking schemes

7. REFERENCES

[1] D. Chamberlain, "Big Trends in Future Cellphones 2007-2012," July 2007.

[2] M. Steer, "Beyond 3G," *IEEE Microwave Magazine*, vol. 8, no. 1, pp. 76-82, Feb 2007.

[3] Y.-J. Choi, K. B. Lee, and S. Bahk, "All-IP 4G Network Architecture for Efficient Mobility and Resource Management," *IEEE Wireless Communications*, pp. 42-46, April 2007.

[4] N. Nasser, A. Hasswa, and H. Hassanein, "Handoffs in fourth generation heterogeneous networks," vol. 44, no. 10, pp. 96-103, October 2006.

[5] A. Hasswa, N. Nasser, and H. Hassanein, "Tramcar: A Context-Aware Cross-Layer Architecture for Next Generation Heterogeneous Wireless Networks," in , Istanbul, June 2006.

[6] A. A. a. S. K. D. N. Banerjee, "Seamless SIP-Based Mobility for Multimedia Applications," vol. 20, no. 2, pp. 6-13, Apr 2006.

[7] E. Karmouch, P. Marti, and H. Hassanein, "mbiTalk: Enhancing Wireless Communication Services Through the Automatic Adaptation of Mobile Communications," pp. 300-307, Jun 2006.

[8] A. Cuevas, J. Moreo, P. Vidales, and H. Einsiedler, "The IMS Service Platform: A Solution for Next-Generation Network Operators to be more than Bit Pipes," vol. 44, no. 8, pp. 75-81, Aug 2006.

[9] 3GPP, " TS 23.234 V7.5.0 (2007-03) Technical Specification Group Services and System Aspects; 3GPP system to Wireless Local Area Network (WLAN) interworking; System description (Release 7)," 2007.

[10] S. Kumudu, A. Munasinghe, and B. Vucetic, "Interworking between WLAN and 3G Cellular Networks: An IMS Based Architecture," in , March 2007.

[11] P. Prasithsangaree and P. Krishnamurthy, "A new authentication mechanism for loosely coupled 3G-WLAN integrated networks," in , May 2004.

[12] N. Crespi and S. Lavaud, "WLAN access to 3G Multimedia Services," in , Bangkok Thailand, Nov 2004, pp. 79-83.

[13] R. f. Comments, "SIP: Session Initiation Protocol," in .

[14] W.-K. C. Huang and F. Hsin, "Network-Initiated Triggering for Mobility in Voice over 3GPP-WLAN," in , 2007.

[15] R. Ermin, "Interworking of IP multimedia core networks

between 3GPP and WLAN," June 2005.

[16] 3. T. 22.934, "Feasibility Study on 3GPP system to Wireless Local Area Network (WLAN) Interworking," vol. 6, no. 2, Sep 2003.

[17] A. Hasswa, A. Taha, and H. Hassanein, "On Extending IMS Services to WLANs," pp. 931-938, 2007.