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An IMS-based network architecture for WiMAX-UMTS and WiMAX-WLAN interworking

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ABSTRACT

The IP Multimedia Subsystem (IMS) seems to be the technology that will prevail in Next Generation Networks (NGNs), since the interworking environment and the service flexibility that this technology offers to the currently deployed wireless broadband technologies makes it appealing to users, service developers and network operators. In this paper we propose a heterogeneous network model based on the IMS that integrates the Worldwide Interoperability for Microwave Access (WiMAX), Universal Mobile Telecommunications System (UMTS) and Wireless Local Area Network (WLAN) technologies and provides guaranteed QoS. We present the complete signalling flow concerning the authorization, registration, session set up and vertical handoff processes, as well as, an analytic model for cost analysis of the proposed architecture.

1. Introduction

Nowadays, several different wireless and wired network technologies exist that try to satisfy the different user needs and requirements. In the near future, network operators will try to combine various technologies in order to build large heterogeneous networks in order to provide the users with better services. However, the design and the development of such networks requires the consideration of different issues, such as the session control, the authorization, the authentication, the Quality of Service (QoS), the charging, the users' mobility, etc.

The IP Multimedia Subsystem (IMS) [1] comes as a promising solution to the above issues, since it offers the needed interworking environment for the integration of, in principle, any broadband wireless access technology, whilst complemented with the necessary gateways it provides access to legacy telecommunications switching systems. Also, since the IMS uses the Session Initiation Protocol (SIP) [2] for session establishment, management, and transformation, its offerings include functions, such as authentication, addressing, routing capability negotiation, service invocation, provisioning, charging, session establishment, etc. However, since the IMS networks are still in an ongoing activity the industry and the research community constantly try to face open issues and extend IMS beyond 3G, by proposing interworking architectures that aim on seamless service provisioning.

In this paper, we propose an interworking model that integrates a Worldwide Interoperability for Microwave Access (WiMAX) network, a Universal Mobile Telecommunications System (UMTS) network and a Wireless Local Area Network (WLAN) in an IMS compatible architecture. More specifically, the proposed architecture incorporates a UMTS Core network (CNet), a WiMAX network and a WLAN network interconnected with the UMTS Core through specific functional entities and an IMS in charge of sessions' control. Thus, users can access the UMTS Circuit-Switched (CS) based services through the WiMAX and WLAN networks, since they are authenticated in the Authentication, Authorization, and Accounting (AAA) Server and registered in the IMS core.

The rest of the paper is organised as follows. Section 2 presents an overview of the IMS including key features, architecture particularities and supported signalling protocols, while Section 3 overviews related work concerning the IMS deployment. Our proposed network architecture is presented and analysed in Section 4. An analytical model for cost analysis of the proposed architecture, as well as, numerical results that are used to evaluate the performance of our proposed architecture are presented in Section 5. Finally, Section 6 concludes the work and discusses some future research directions.

2. The IP Multimedia Subsystem – overview and key features

The IMS is a framework that was first designed and standardized by the 3GPP (3rd Generation Partnership Project) [1,3] with

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main goal the provision of the Internet Protocol (IP) [4] based telephony and multimedia services over 3G networks. It has been also extended by the 3GPP, 3GPP2 and TISPAN towards integrating different broadband wireless technologies, such as WLAN, CDMA2000, UMTS, WiMAX and also fixed line networks. The IMS provides horizontally integrated services and access independence supported by functions such as authentication, addressing, routing capability negotiation, service invocation, provisioning, charging, session establishment, etc.

As depicted in Fig. 1, the IMS is a 3-layer architecture that consists of the Transport Layer, which includes all the entities for the supported access networks; the Control Layer where the core IMS network resides; whereas at the top exists the Service Layer which includes the application servers hosting the IMS services. It should to be noted that the 3GPP standardises functions and not physical components; thus, IMS deployments can combine or split these functions, referred to also as functional entities, into different physical network components.

The 3GPP IMS Reference Architecture defines various functional entities and the interfaces among them. The key entities of the IMS core include the user database(s) namely the Home Subscriber Servers HSSs and the Subscriber Location Functions (SLFs); the SIP servers known as Call-Session Control Functions (CSCFs); the Applications Servers (ASs); the Media Resource Functions (MRFs), the Breakout Gateway Control Functions (BGCFs) and the Public Switched Telephone Network (PSTN) gateways.

The HSS is the master database for a domain, where the profile of a given user is stored. A Home Network may contain one or several HSSs, depending on the number of mobile subscribers, on the capacity of the physical component where the HSS resides and on the overall structure and design of the network. The presence of the Subscription Location Function (SLF) is dictated by the existence of more than one HSS in a network and its main role is to respond to nodes' queries on the HSS handling a particular user.

The CSCF is an essential node in the IMS that processes the SIP signalling. There are three types of CSCFs, referred to also as SIP Servers: the Proxy-CSCF (P-CSCF), the Interrogating-CSCF (I-SCSF) and the Serving-CSCF (S-CSCF) servers.

The P-CSCF server is the first point of contact for a User Equipment (UE) entering the IMS subsystem. Its address is discovered by the UE and its goals are to perform the registration of the UE, to compress/decompress SIP messages, to generate charging records and to enforce policies through the Policy Decision Function (PDF), whilst it can be located either in the Home Network or in the Visited one.

The I-CSCF server is the SIP proxy that resides at the administrative functional domain of the IMS. It queries the HSS in order to determine the location of a UE and routes UE's messages to its assigned S-CSCF. The I-CSCF is usually located at the Home Network whilst towards enhancing the network's redundancy and scalability a number of I-CSCFs can be deployed in the same network.

The S-CSCF server is the entity that controls the sessions and maintains the correlation between the UE's SIP addresses. An S-CSCF is assigned to each UE during its registration to the IMS, however each S-CSCF may serve more than one UEs, depending on the capacity of the physical component the S-CSCF resides. The S-CSCF is responsible to forward the SIP messages to the appropriate AS and to enforce the service policies of the network operator.

In addition to the above IMS core entities, additional ones have been standardized towards completing the IMS interworking environment. The Breakout Gateway Control Function (BGCF) provides routing functionality based on telephone numbers; thus it serves sessions addressed to circuit-switched network users. Alongside with the Media Gateway Controller Function (MGCF) and the IMS-Media Gateway (IMS-MG) they provide connectivity between the IMS and circuit-switched networks.

As clearly presented above, the communication between the various IMS entities is achieved through standardized interfaces and protocols; thus making the IMS easily expandable. With reference to the 3GPP IMS Reference Architecture (Fig. 2), Table 1 summarises the IMS interfaces and protocols.

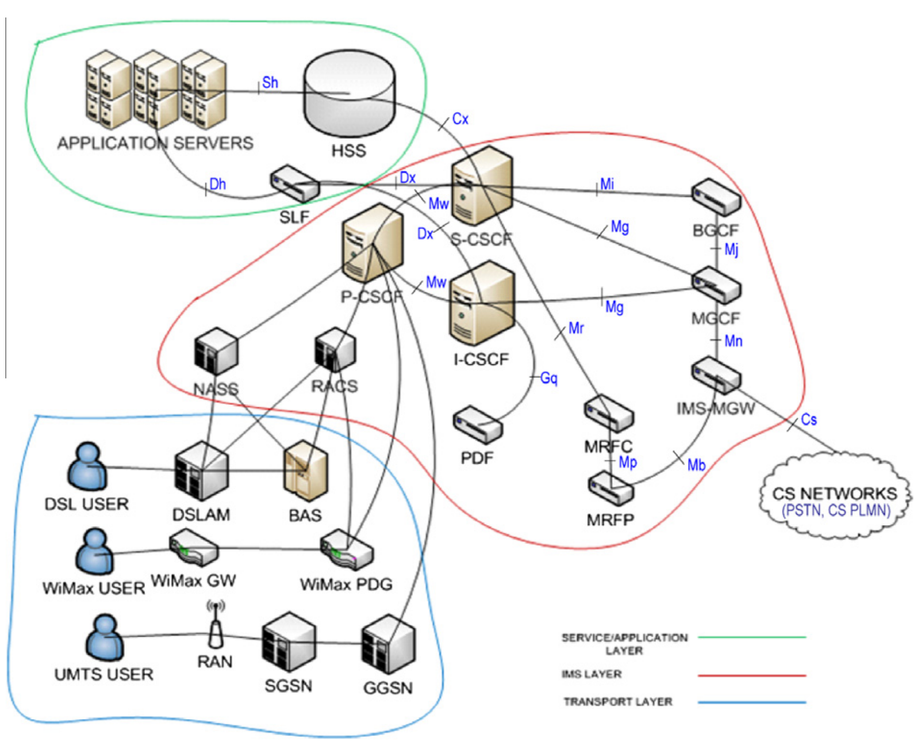

Fig. 1. The IMS 3-layer architecture.