IP Multimedia Subsystem - IMS: Converged Network Architecture for the Intelligent Interaction of Network Applications and Services

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Abstract

In this paper, we analyze the ability of IMS to converged various network architectures and provide the intelligent interaction of applications and services. We describe the IMS architecture. IMS distributes much of the intelligence to the communications device or the edge of the network, allowing carriers to develop multimedia services that can be delivered and managed across diverse access networks. Additionally, the operation of IMS is carried out. How can IMS provides more efficient service provisioning capabilities, in the meantime it also increases overall service transparency and control. After that, the signalling in IMS is expressed. In this section we examine the use of SIP signalling in IMS environment. The difference between IMS signalling and SS7 signalling is depicted as well. Finally, it can be concluded that The IMS allows an evolutionary move to all-IP converged networks. It provides flexible session control with desirable features such as guaranteed end-to-end QoS, roaming capabilities, security, and easy and convenient charging.

Key words: IMS, fixed-mobile convergence, all-IP network, VoIP.

I. Introduction

IP Multimedia Subsystem (IMS) is a new framework, basically specified for mobile networks, for providing Internet Protocol (IP) telecommunication services. It has been introduced by the Third Generation Partnership Project (3GPP) in two phases (release 5 and release 6) for Universal Mobile Telecommunications System (UMTS) networks. An IP multimedia framework was later introduced by 3GPP2 as the Multi Media Domain (MMD) for third generation Code Division Multiple Access 2000 (CDMA2000) networks, and finally harmonized with IMS. Real-time services can only be properly supported using the release 6 IMS specifications.

The IP Multimedia Subsystem (IMS) standard defines a generic architecture for offering Voice over IP (VoIP) and multimedia services. It is an international, recognized standard, first specified by the Third Generation Partnership Project (3GPP/3GPP2) and now being embraced by other standards bodies including ETSI/TISPAN. The standard supports multiple access types–including GSM, WCDMA, CDMA2000, Wireline broadband access and WLAN.

For users, IMS-based services enable person-to-person and person-to-content communications in a variety of modes – including voice, text, pictures and video, or any combination of these – in a highly personalized and controlled way.

For operators, IMS takes the concept of layered architecture one step further by defining a horizontal architecture, where service enablers and common functions can be reused for multiple applications. The horizontal architecture in IMS also specifies interoperability and roaming, and provides bearer control, charging and security. What is more, it is well integrated with existing voice and data networks, while adopting many of the key benefits of the IT domain.

This makes IMS a key enabler for fixed-mobile convergence. For these reasons, IMS will become preferred solution for fixed and mobile operators' multimedia business. The integration of different media opens up new possibilities for far richer services than those available today and for which users will probably be willing to pay IMS is concerned with the creation and deployment of multimedia telecommunication services over any IP network. Importantly, this includes person-to-person real time services (such as voice) over Packet Switched (PS) networks, removing the need for a Circuit Switched (CS) domain. However, emulation of mobile CS services is not the primary goal of IMS, although their replacement by IMS services is unavoidable in the long run. Furthermore, it will be necessary for IMS to interwork with external CS networks, such as the Public Switched Telephone Network (PSTN) and Public Land Mobile Network (PLMN), even if there is no longer a circuit switched core network domain.

II. IMS Architectural Overview

IMS distributes much of the intelligence to the communications device or the edge of the network, allowing carriers to develop multimedia services that can be delivered and managed across diverse access networks. Because service intelligence is largely distributed to the edge of the network or to the communications device, network operators can more swiftly create enhanced services that can be provisioned across multiple networks. IMS is a strategic technology for next-generation services, and it is offers a standards-based architecture for critical functions such as:

- Call control
- Presence
- Location
- Content-based billing
- Profile management
- Convergence
- Service interaction
- Abstract data management and distribution

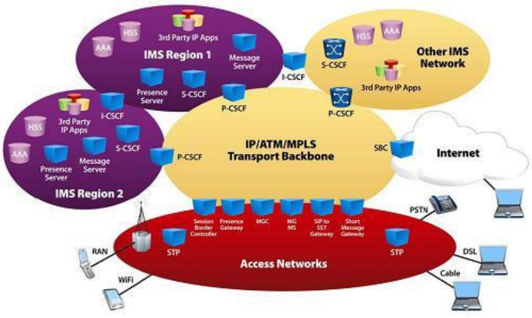

Figure 1. IMS general architecture: converged network architecture for the intelligent interaction of applications and services.

Network operators create a single IP, asynchronous transfer mode (ATM), or multi-protocol label switching (MPLS) core network for transport, and they can implement IMS architecture across mobile and/or fixed networks. Subscribers can be provided with flexible means of accessing services delivered over IMS infrastructure. They can access IMS services by dialing up over the PSTN, or they can benefit from more rich multimedia services by accessing the infrastructure through the PSTN using digital subscriber line (DSL) services. They can also access IMS services via broadband cable technology, and mobile users can reap the benefits of IMS via cell phones or WiFi connections.

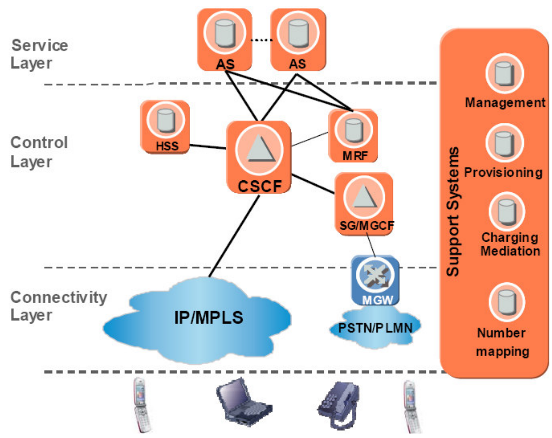

Figure 2. Layered architecture in IMS

The ***application layer*** comprises application and content servers to execute value-added services for the user. Generic service enablers as defined in the IMS standard (such as *presence* and *group list management*) are implemented as services in a SIP Application Server. The application or service layer contains application servers (ASs) such as the SIP AS, third-party open service access (OSA) AS, and legacy service control point (SCP) AS. The IMS controls service via the subscriber's home network and those signaling network elements distributed in the application layer and the control layer. This arrangement enables subscribers to receive the same types of services while they are roaming.

The ***control layer*** comprises network control servers for managing call or session set-up, modification and release. The most important of these is the CSCF (Call Session Control Function), also known as a SIP server. This layer also contains a full suite of support functions, such as provisioning, charging and operation and management (O&M). Interworking with other operators' networks and or other types of networks is handled by border gateways. The heart of the control layer consists of the call session control function (CSCF) servers, also known as SIP servers. This layer also includes the home subscriber server (HSS) database, subscriber location function (SLF) database, PDF, and breakout gateway control function (BGCF).

The ***connectivity layer*** comprises routers and switches, both for the backbone and the access network. The connectivity or access layer is used to transport signaling traffic and media streams. This layer contains switches, router, and media processing entities (MGWs, signaling gateways [SGWs], MRF controls [MRFCs], and MRF processors [MRFPs]). Since IMS is designed to be access independent, it can connect to different types of existing and emerging access networks as long as they have IP connectivity. Access networks that can connect with the IMS include GPRS/UMTS, 2G networks such as GSM via gateways, PSTNs via gateways, enterprise fixed networks via IP Centrex, residential fixed networks via xDSL or cable modem, WLANs, and worldwide interoperability for microwave access (WiMAX).

III. The IMS Operation

In circuit-switched and packet-switched networks, the provisioning of services is controlled by the application, but this makes service interaction complex and reduces overall service transparency and control. In contrast, IMS provides more efficient service provisioning capabilities. When a user registers on the IMS network, a subscriber service profile (SSP) is downloaded by the S-CSCF from the HSS.

The SSP contains service-related information and identifies the services that need to be provisioned. If multiple services need to be implemented, it determines the order in which they are provisioned. The SSP also includes the address of the server (or servers) that must execute the subscriber's request. This approach allows IMS to serve as a re-usable service infrastructure by letting providers control and manage the complexities involved in service filtering, triggering, and interaction. Network operators can integrate services for both packet-switched and circuit-switched networks into a single session, and users can add multimedia services to existing services in real time.

One way to learn about the IMS architecture is to review a sample implementation. Figure 3 below represents how IMS logical functions interact to support a few sample applications.

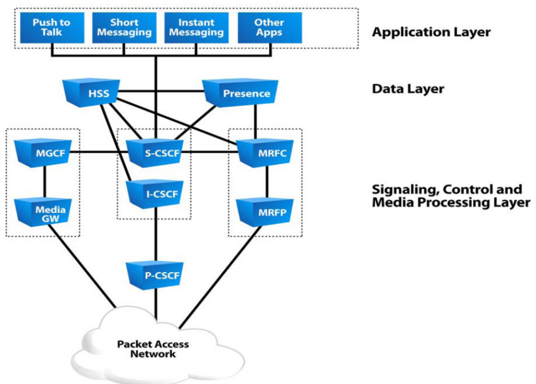

Figure 3. Interact of IMS logical functions

In this example, push-to-talk, short messaging, and instant messaging all leverage a common infrastructure to enable the efficient delivery of multimedia services. Services are developed in SIP and hosted on application servers. The network operator can swiftly create additional services that repurpose application code and can leverage the underlying infrastructure to offer new services in the future.

These applications leverage data layer logical functions, elements, and features. For example, all of these applications rely on the HSS to manage subscriber information and enable users or servers to locate targets. The SIP applications also leverage user presence information. The network operator would only have to write the logic to manage presence once, and allow current and future applications to tap into this logic to incorporate presence information

The I-CSCF and S-CSCF functions provide access to the signaling network for the applications and prevent foreign networks from gaining visibility into the network. The MRFC provides the intelligence to instruct the MFRP to process the media resources, while the MGCF instructs the MG to deliver the media services to the session. Together, the MGCF and MG deliver media services to-and-from the PSTN.

The P-CSCF at the edge of the packet access network serves as a proxy. If the session involves more than two members, multiple P-CSCFs might be involved in the session control function.

Before a user can access IMS service, the IMS terminal must perform three major tasks:
Access the IMS home or visited network via the IP connectivity access network (IP-CAN), discover the P-CSCF address, and perform IMS level registration. The IP-CAN could be GPRS/UMTS, WLAN, or xDSL, although Release 5 of the 3GPP (the first release of the IMS) supports only GPRS/UMTS. Thus, the IMS terminal must perform a *GPRS Attach* with the serving GPRS support node (SGSN) and perform bearer level authentication with the HLR. To discover the IP address of the P-CSCF, which is stored at the GGSN, the terminal must perform a packet data protocol (PDP) context activation with the GGSN. Finally, the terminal must perform IMS level registration with the CSCF and the HSS. At this point, the IMS terminal can access various applications on Ass via the CSCF.

IV. Signalling in IMS

SS7 signaling is used in 2.5G networks to provide user authentication, mobility management, call control, and messaging. The Mobile Application Part (MAP) is the SS7 protocol used to managed presence and location information for a subscriber served by the Mobile Switching Centre (MSC) and its corresponding Visitor Location Register (VLR). The Home Location Register (HLR) is the central database for subscriber location and other service profiles needed to authorize value added services. The CAMEL Application Part (CAP) enables intelligent network services and supports service mobility as the user moves between different serving areas. Both MAP and CAP use TCAP protocols over SS7 transport layers.

SIP signaling is the primary method for user registration and session control in the IMS architecture. The Call Session Control Function (CSCF) is the core signaling server in the IMS networks architecture. It acts as both a SIP Registrar and stateful SIP proxy server. The 3GPP, as already mentioned at section 2 above, defines three of CSCF network elements: Proxy, Interrogating, and serving CSCF.

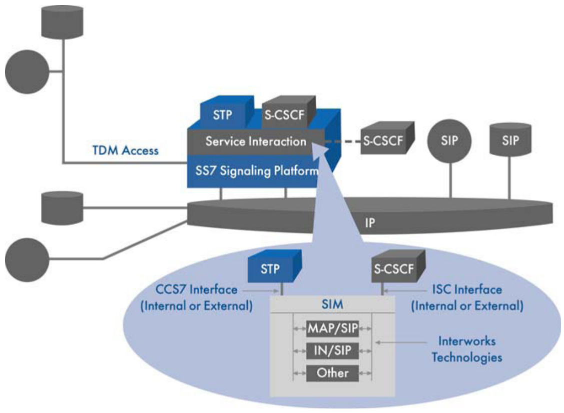

Figure 4.The CSCF function on the signalling platform enables the interworking of SS7 and SIP-domain services.

Some network providers may elect to combine these functions or deploy these services on separate server platforms. The Serving CSCF manages all IMS service requests for the subscriber and is the element illustrated in figure 4. The Home Subscriber Server (HSS) is the 3G IMS equivalent to the HLR, providing AAA functions and maintaining subscriber profile data in central location. The CSCF uses Diameter protocols to perform user authorization and retrieve subscriber service profiles from the HSS. Application servers use Diameter to retrieve and update subscriber information and service profiles. Application invoke SIP-based Media Server resources to offer services such as ad hoc conferencing, audio or video streaming, media conversion (e.g. text to speech, automatic speech recognition), and basic audio announcements. The Media gateway Control Function controls the media conversion (circuit to packet) for calls that originate or terminate in the switched circuit network and require access to IMS services.

The HSS is a stateless Diameter server, which stores subscribers' profiles (e.g., user identities), registration (e.g., location and authentication parameters), and service logic information (e.g., filtering criteria and trigger points) information. It may also support Home Location Register/Authentication Center (HLR/AuC) functionality and Mobile Application Part (MAP)-based interfaces for legacy 2G and 2.5G networks. Subscriber data stored in the HSS is the key enabler for service mobility across different types of access networks and user roaming between different network operators.

To describe SIP and Diameter-based signaling procedures in the IMS Core, two examples are given below. The first example shows an initial registration procedure (see figure 5), which assumes the user roams to a visited network. This procedure starts with the user's SIP REGISTER request being sent to the visited P-CSCF. Due to air interface bandwidth limitation, messages are compressed before being sent out by the user and are decompressed at the P-CSCF. If multiple S-CSCFs exist in the user's home network, an I-CSCF needs to be deployed for selecting an S-CSCF for serving the user session. In this case, the P-CSCF resolves the address of the user's home I-CSCF using the user's home domain name and forwards the REGISTER to the I-CSCF. After the I-CSCF sends a User-Authorization-Request (UAR) to the HSS, which returns available S-CSCF addresses, the I-CSCF selects one S-CSCF and forwards the REGISTER message.

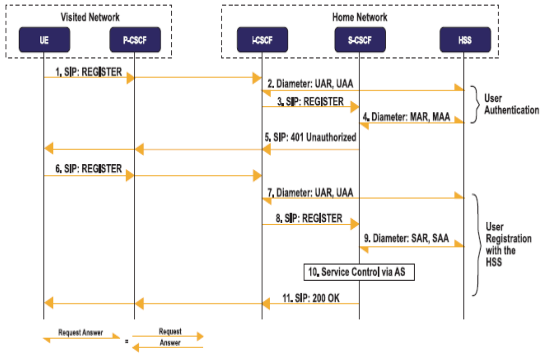

Figure 5. Signalling message flow of registration

V. System Interoperability

Traditional CS (e.g., PSTN, GSM) voice service will coexist with PS multimedia services. Therefore, it is critical to provide interoperability between IMS and CS-based voice services. To this end, the IMS provides a distributed softswitching architecture, which comprises the following network elements:

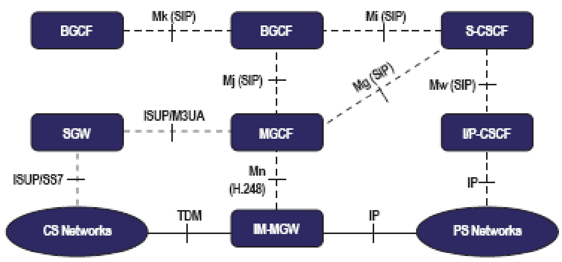

Figure 6. IMS – Circuit Switch interoperability Architecture

- **Signaling Gateway (SGW)**, which converts the transport of the ISDN User Part (ISUP) protocol between Message Transfer Part 3 (MTP3) and MTP3 User Adaptation (M3UA).
- **IM Media Gateway (IM-MGW)**, which converts media format provided in one type of network to the format required in another type of network (e.g., from the Time Division Multiplexing (TDM)-based format to the IP-based format).

- **Media Gateway Control Function (MGCF)**, which acts as a SIP UA and translates signalling messages between SIP and ISUP. It also controls the media conversion in one or multiple IM-MGWs using the media gateway control protocol, H.248, according to received ISUP or SIP messages.
- **Breakout Gateway Control Function (BGCF)**, which determines where the interworking should occur when a session is originated from an IMS user. If the interworking occurs in the same network, the BGCF will select an MGCF; otherwise, it contacts a BGCF belonging to another network (operator), where the interworking will take place.

VI. Conclusions

In this paper we have describe that the IMS allows an *evolutionary* move to all-IP converged networks. But in terms of capabilities and features offered, the IMS is truly a *revolutionary* approach to multimedia, multisession service deployment. It provides flexible session control with desirable features such as guaranteed end-to-end QoS, roaming capabilities, security, and easy and convenient charging. It also allows horizontal service deployment by offering a common platform with reusable components and open interfaces.

With the IMS in place, services and applications can be deployed more quickly, easily, and economically than ever before. Because IMS is IP based, it will blend telecommunication and data services, keeping the best of both the circuit-switched and packet worlds.

Acknowledgment

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