

IMS

Technologies and Architecture

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“Nascent customer demand for multimedia services delivered anytime and anywhere is driving the acceptance and take-up of all-IP networks. Supporting this requirement demands high performance architectures and protocols, of which 3GPP’s IP Multimedia Subsystem (IMS) is the most appropriate. This paper is an overview of the key technologies and architecture of IMS and is suitable for IT professionals and managers interested in the new IMS-based platforms and the consequences of their introduction.”

Introduction

Increasingly the telecommunications industry is looking to provide customers with the benefits of ubiquitous roaming. Particularly so if customers are allowed to engage in realtime activities such as VoIP, online gaming, video conferencing and instant messaging, in addition to non-realtime data transfers such as email and web traffic. This is in large part due to the anticipated high revenue growth derived from charging for new services and the dislocation of existing fixed line operations from their pre-eminent position. Also whetting the appetite of those involved are the opportunities for lower costs from having one system deliver all services – including voice. In some ways, the idea of using mobile devices in ways that we would normally identify with a PC is natural. It is born from the convergence – and extrapolation – in our minds of the two biggest technological successes in recent years: the Internet and mobile communication.

Standardisation

Industry Standards

In order for this vision to be more than just loose talk though, the international telecommunications and research communities have joined in a collaborative effort. They share a common understanding that Internet Protocol (IP), the Internet addressing and delivery technology, is the best mechanism for mobile operators to transport all types of data in future. IP, of course, is a well-established technology; several IP-based technologies coexist at the moment: such as some cellular networks (GPRS/UMTS) and WiMAX; wired networks such as DSL; and personnel wireless solutions such as WLAN (802.11 a/b/g/n). In addition, there are emerging platforms that promise greater speed and throughput than the present-day incarnations. These include 3GPP's (Third Generation Partnership Project) Evolved UMTS Terrestrial Radio Access Network (E-UTRAN), an ultra-fast cellular network, part of a much bigger undertaking, the Long Term Evolution (LTE)

project. 3GPP is best known for fathering the UMTS and GSM standards. Similar platforms include 3GPP2's Ultra Mobile Broadband. 3GPP2 oversee the CDMA cellular specification. Even with all this diversity, the new technologies are all converging on a shared goal: to deliver a secure cost-effective, high-speed all-IP system with global reach.

Collaboration

The same industry bodies are sponsoring much of the recent research into the all-IP network. There is huge commercial interest in pushing the next cycle of innovation in network equipment and user services. In the past, peaks in this cycle have coincided with large sales growth. Nevertheless, many inside and out of the commercial sector have come to believe that IP cores will dominate future networks. Hence they have been identified as the logical next step for traditional providers of cellular networks. To this end, the telecoms and network infrastructure companies have formed a number of influential groups, most notably: 3GPP, 3GPP2 and ITU-T (International Telecommunication Union Telecommunication Standardization Sector).

Collaborating with these telecoms bodies has been the Internet Engineering Task Force, an authoritative independent standardisation body. Areas of close cooperation include joint work on IPv6, DNS, and multimedia related protocols. 3GPP, for example, have approved for their member's networks a number of protocols and architectures sanctioned by the IETF: they adopted – and worked to enhance – Session Initiation Protocol (SIP) for session control; Session Description Protocol for describing multimedia communication sessions; Diameter for authentication, authorisation and accounting; and

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Realtime Transport Protocol for multimedia packet delivery.

Mobility

The ability to contact someone, or something, anywhere in the world presented a problem for the research and cellular industry: how do we provide uninterrupted communication between participants when they are on the move?

Managing the movement of devices and people within the proposed all-IP networks whilst keeping data traffic flowing is the responsibility of the mobility management solutions available. The research community have advanced a number of solutions to this mobility problem in recent years. At the network layer, Mobile IP and its more recent sibling Mobile IP for IPv6 (MIP), allow for imperceptible changes to the underlying IP address of the device. However, their performance for real-time applications has been questioned.

At the application layer, SIP is a standard designed to manage sessions. It is a versatile protocol though, and has been shown to provide support for mobility. SIP is a particularly suitable mechanism for setting up and delivering sessions that demand a high quality-of-service (QoS) (i.e. applications that require a minimum bandwidth and low delay, jitter, and loss rate). Typically, this would be for realtime applications, which are often multimedia in nature (e.g. VoIP, gaming and video messaging). Unsurprisingly SIP was an attractive technology for the telecoms industry.

IP Multimedia Subsystem

Building on this existing work the IETF and several of the telecoms bodies are progressing towards defining and building core network architectures and protocols that employ IP technology and support high-performance multimedia sessions. The most visible of which is 3GPP's proposed IP Multimedia Subsystem (IMS). Figure 2 presents an abridged illustration of the main components of IMS.

IMS is a collection of interrelated functional areas designed

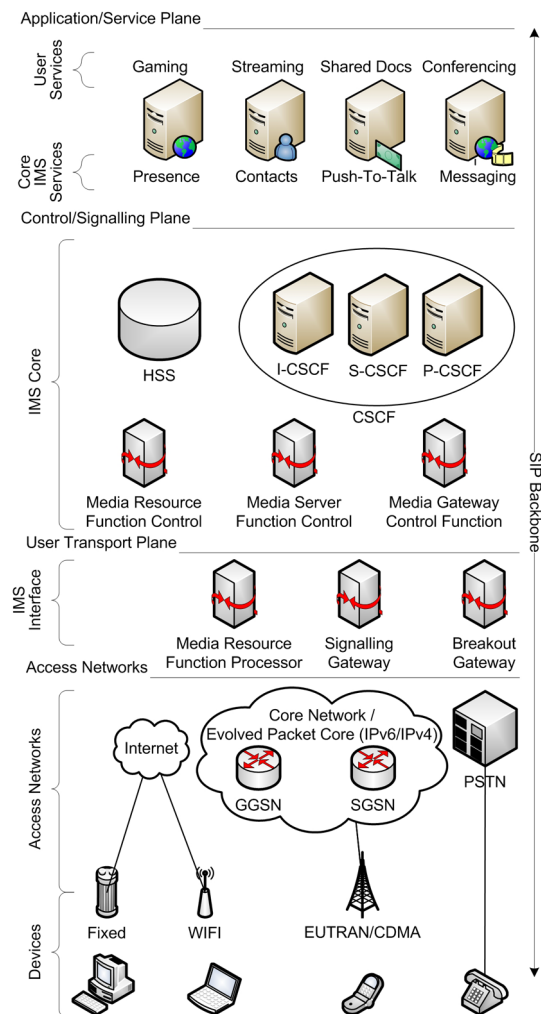


Figure 2. IMS Architecture (3GPP)

for the delivery of multimedia services to users. Its structure allows carriers to rapidly create new user services (the top layer in Figure 2) and applications and deploy them to customers in an access independent manner (the bottom layer). That is, regardless of the device type or access technology the customer has available. It creates a unified signalling, management and control system based on the SIP standard (the IMS Core layer) for any IP network (the IMS Interfaces layer), be that WiMax, Wi-Fi, cellular or DSL. A service – say, a video conference or voice call – can connect to a number of users independent of their location, device they are using, or the sort of access network they are connected to. It permits more accurate user identification; the advertisement of their status and capabilities of their device; and affords full control over the delivery of services they are authorised

to use and receive. In summary, IMS is a mobile IP network designed to support SIP functionality with additional routing, security and location management functions.

Consequently, IMS is providing a catalyst for current mobile network operators to move their business models away from the simple provision of the physical plumbing and hardware for mobile communications, towards a fully-fledged service model.

The key components of IMS are the services and the core infrastructure. The Call Session Control Function (CSCF) servers and the Home Subscriber Service (HSS) make up the core. The CSCF servers support SIP setup and session management. The HSS, on the other hand, is the master database of customer data that assists in the following functions: to allow subscribers to locate and communicate with each other; to support session setup and provisioning; and provide authentication and authorisation capabilities. Within the IMS infrastructure, devices gain attachment from the Internet via the Gateway GPRS Support Node or from the cellular network via the Serving GPRS Support Node. Alternatively, and to ease deployment, there are media gateways into the IMS core for traditional voice calls over the existing Public Switched Telephone Network (PSTN). Once authenticated within IMS, the subscriber can initiate a service, such as a Voice over IP (VoIP) call, through an exchange of SIP messages. This occurs in

the logical “control plane”, where all signalling messages occur. The subsequent movement of data between end-points occurs in the “media” or “transport plane”.

A rich set of services are available out of the box from the standard application servers. Services include core functions such as a centralised address book, presence, messaging and voice. In addition, third party developers can plug in applications to provide more feature rich online services such as shared files, gaming or conferencing. The core IMS architecture fits logically in the middle between the service publishers (servers) and the subscribers (users).

CSCFs

Figure 3 depicts the SIP message flow between two mobile device users, and within the CSCF servers. The servers provide much of the same functionality as an orthodox SIP proxy server and register. The Serving CSCF server (S-CSCF), one of the three that make up the CSCF triumvirate, is the SIP server that performs user registration, manages session control, interacts with the services layer, and is charged with accounting for usage. Users never interact directly with the S-CSCF, instead, they communicate only via the Proxy CSCF server (P-CSCF). Hence, the P-CSCF receives all SIP signalling from users. Every domain the user visits allocates a dedicated P-CSCF to them during the registration process. At a low level the

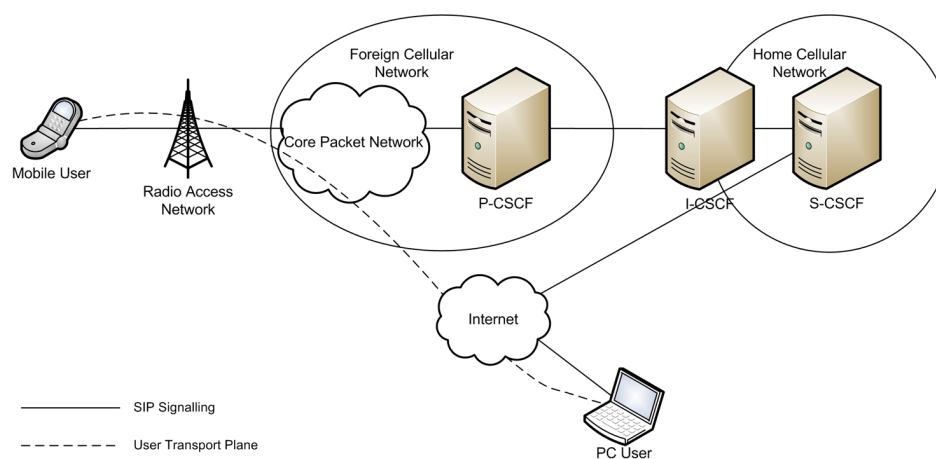


Figure 3. SIP Messaging in IMS

server provides data compression, secure data transmission and authorisation services. However, its primary function is to route signalling traffic to the S-CSCF for processing. The Interrogating CSCF server is a proxy server. It acts on behalf of the S-CSCF, and provides a domain gateway for P-CSCFs from fellow IMS networks, and routes the transmission onto the S-CSCF assigned to the user by the HSS.

IMS History

3GPP introduced IMS in a standard called Release 5 in early 2002. The standard specified what the core network should look like and provided for compatibility with existing networks such as GSM and UMTS. Release 6, in late 2004, added to IMS's functionality with support for the Generic Access Network, what is commonly called heterogeneous access (e.g. from Wireless LANs (WLAN) or DSL etc). Also included were new core services such as presence and conferencing, plus the optional support for IPv4 (IMS uses IPv6 natively). In 2007, Release 7 included VoIP technology. And as of early-2009, 3GPP ratified Release 8, which deals with the next generation – the 4th in this case – of wireless network infrastructure under the auspices of the Long Term Evolution (LTE) project .

Long Term Evolution

LTE is a long-term vision and roadmap for the telecoms industry. It describes an all-IP cellular network (E-UTRAN) with end-to-end QoS and access independence. At the centre, it employs IMS to provide services and applications to the end user. SIP provides for all mobility related requirements. 3GPP are proponents of using an IPv6-based core network, and LTE is no exception. (Although it has introduced some support for IPv4 at the periphery using Dual Stack MIPv6.)

Many large network vendors, carriers and providers are committed to the vision outlined in LTE. However, even

that endorsement is no guarantee of success – WiMAX, for one, presents a strong competitive challenge in certain settings. Furthermore, IMS has had limited take-up so far.

That may be about to change though. The FCC, the US government's communications watchdog, stipulated that the March 2008 auction of spectrum (the 700MHz spectrum) must meet stringent application access criteria. Verizon, who eventually won the bidding, will use LTE based on a modified IMS architecture, A-IMS (referred to as 'Advances to IMS') to provide those services. In parallel, they have launched the Open Development Initiative in March 2008 to meet the FCC's initiative to open the architecture to software developers and service providers. It is likely they will release a limited form of A-IMS in 2011. Thus, it appears increasingly probable that IMS will have a part to play in future cellular networks. And a potentially commanding one.

CDMA

But what of CDMA-based networks? 3GPP2, its guardian, have adopted a modified form of IMS for their CDMA sponsored networks: known as Multimedia Domain (MMD). There are some important changes over 3GPP's IMS, although much of the standard is taken straight from the IMS documentation. For example, in MMD, the mobile device can host IPv4 alone or IPv4 and IPv6 together. Therefore, MIPv4 over IPv4 or MIPv6 over IPv6 is possible.

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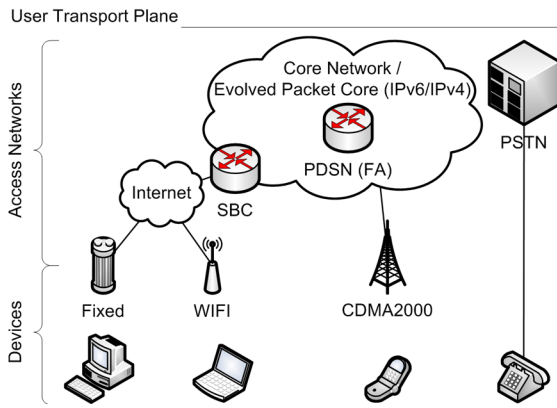


Figure 4. MMS Architecture (3GPP2)

Figure 4 illustrates MMD's user transport plane. This is where most of the differences between 3GPP and 3GPP2's approaches reside - the remaining parts of the MMD architecture are very similar to IMS. Modifications to the infrastructure include a number of new servers with position-related functionality. Furthermore, within 3GPP2's MMD infrastructure, the device gains attachment to the network via the packet data switching node (PDSN). Since 3GPP2 provides support for MIPv4, the PDSN acts as a foreign agent (FA) or home agent (HA).

Additional network devices, Session Border Controllers (SBC), are placed at the border of the core IP network. In IMS, the devices are called border control functions. Figure 4 depicts a situation where the core network is separated from the Internet via an SBC. They function as an IP gateway, deployed between the operator's network and other networks in order to provide NAT traversal, Service Level Agreements, security and QoS functions.

Future Network Characteristics

It is by no means certain that the organisations pushing

IMS or MMD will prevail. But there are certain concepts that have enough momentum that it is likely they will become an accepted part of any future network. These include:

- An all-IP infrastructure.
- Access to and from diverse technologies.
- Ultra-fast ubiquitous connectivity.
- A proliferation of applications and services.

Given the effect the Internet has had on the explosion of new, previously unthought-of services, in future we can confidently predict that consumers will operate within an environment of greater choice and diversity of wireless communication than what we have today. We give this idea the moniker 'heterogeneity'. Examples that are more specific include the assortment of access network technologies available; and as we have seen a glimpse of today, the numerous services available from different carriers.

With regard to the number and variety of access technologies, it is not yet certain that the numbers will proliferate in future; we may see consolidation around a dominant ubiquitous technology like WiMAX or E-UTRAN. Whatever the case, it is highly likely that there will be different networks available, and that users will discriminate between them for many reasons. That said, customers are increasingly expecting their services to be provided regardless of the access technology used. And invariably, they want to perceive the service in an inconspicuous and continuous manner. This presents a number of challenges, but also a number of opportunities for those that can deliver services and products within this emerging communications environment.

Further Reading

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James Wright MSc is the founder of Konnetic, a specialist in providing SIP and IMS based software to the .NET (C#, VB.NET, F# and more) community.