**IP MULTIMEDIA SUBSYSTEM (IMS)**

**INTRODUCTION**

1. IMS is a label that has started springing up all over the telecom industry, whether on individual products, or as vendor systems platforms or interoperability programs. It’s the acronym for IP Multimedia Subsystem, and it is very important, a big vision of the future of telecommunications hangs on it. It’s also very, very complicated and pretty abstract. A concept developed and specified by the 3rd Generation Partnership Project (3GPP). 3GPP is a collaboration agreement established in December 1998 among various standards bodies, currently comprising:

   (a) Alliance for Telecommunications Industry Solutions (ATIS)
   (b) Association of Radio Industries and Businesses (ARIB)
   (c) China Communications Standards Association (CCSA)
   (d) European Telecommunications Standards Institute (ETSI)
   (e) Telecommunications Technology Association (TTA)
   (f) Telecommunication Technology Committee (TTC)

![Diagram of IMS Facilitate](image)

**Figure 1. IMS Facilitate**

**KEY POINTS FOR BASIC UNDERSTANDING OF IMS**

2. IMS started as a technology for 3G mobile networks (under the auspices of the 3rd Generation Partnership Project (3GPP)), but it is now spreading to next-generation wireline networks and is going to be a key to fixed/mobile convergence. It builds on the Session Initiation Protocol (SIP), which has emerged as the crucial technology for controlling communications in IP-based next-generation networks (NGNs).
(a) IMS is about services and applications, enabling telecommunications, mobile operators, and other service providers to offer rich multimedia services across both next-generation packet-switched and (within obvious limits) traditional circuit-switched networks. It is standards-based and uses open interfaces and functional components that can be assembled flexibly into hardware and software systems to support real-time interactive services and applications.

(b) IMS will have a major impact on the telecom industry including telecommunications, mobile operators, service providers, vendors, and others because it will lead to new business models and opportunities, and (hopefully) lower costs through standards-based procurement. It simultaneously lets network owners derive added value from their networks, while opening these networks to third parties (including enterprise customers) to develop and offer enhanced and tailored services and applications of their own. The full exploitation of mass market broadband will depend on it.

Key Elements:

- AS – Application Server
- SCIM - Service Capability Interaction Manager
- MRFC - Multimedia Resource Function Controller
- MRFP - Multimedia Resource Function Processor
- MRF – Media Resource Function
- CSCF - Call Session Control Function
- BGCF - Breakout Gateway Control Function
- MGCF - Media Gateway Control Function
- MGW - Media Gateway
- HSS - Home Subscription Server
- HLR - Home Location Register

Figure 2. Simplified diagram of IMS

(c) The basic set of standards for IMS implementation were released in 2004, and the first implementations are in hand or planned. Both the International Telecommunication Union (ITU) and the European Telecommunications Standards Institute (ETSI) are heavily involved, and IMS standards are still developing to fill in the inevitable gaps and to add new capabilities. However,
IMS is still untested in real-life major carrier networks, and its wide scale implementation is some years away.

3. Support for IMS even at this early stage in its development seems to be fairly hard-nosed, if the results of a poll taken during the Light Reading Webinar on which some of this report is based IMS. A Blueprint for Fixed-Mobile Convergence are typical:

(a) Just over 40% of respondents thought that the most important catalyst for IMS deployment was the service providers’ need to create a more flexible environment for the deployment of applications.

(b) 18% thought it was service providers’ need to create a converged fixed and mobile network.

(c) 17% thought it was service providers’ need to deploy blended or combinational multimedia applications. In other words, a large majority in favor of pragmatic flexibility, rather than any fancy and/or more futuristic possibilities.

4. The original aim of 3GPP was to specify a third-generation mobile system based on evolved GSM core networks and the radio access technologies they support, but this was subsequently extended to include the maintenance and development of the GSM technical specifications and technical reports, including evolved radio access technologies. IMS is a result of this program.

5. IMS increases the functionality of packet-switched mobile networks (such as 3G GSM) by supporting IP-based applications and services through the Session Initiation Protocol (SIP). However, the rapid spread of fixed-network broadband and the offering of services such as transactions, content distribution, and VoIP (Voice over IP) over all-IP networks have made IMS increasingly relevant to fixed operators as well.

6. Effectively, IMS provides a unified architecture that supports a wide range of IP-based services over both packet- and circuit-switched networks, employing a range of different wireless and fixed access technologies. A user could, for example, pay for and download a video clip to a chosen mobile or fixed device and subsequently use some of this material to create a multimedia message for delivery to friends on many different networks. A single IMS presence-and-availability engine could track a user’s presence and availability across mobile, fixed, and broadband networks, or a user could maintain a single integrated contact list for all types of communications.

7. A key point of IMS is that it is intended as an open-systems architecture: Services are created and delivered by a wide range of highly distributed systems (real-time and non-real-time, possibly owned by different parties) cooperating with each other. It is a different approach to the more traditional telco architecture of a set of specific network elements implemented as a single telco-controlled infrastructure.

(a) IP Multimedia Subsystem is standardized reference architecture. IMS consists of session control, connection control and an applications services framework along with subscriber and services data. It enables new converged voice and data services, while allowing for the interoperability of these converged services between internet and cellular subscribers. IMS uses open standard IP
protocols, defined by the Internet Engineering Task Force (IETF). So users will be able to execute all their services when roaming as well as from their home networks. So, a multimedia session between two IMS users, between an IMS user and a user on the Internet, and between two users on the Internet is established using exactly the same protocol. Moreover, the interfaces for service developers are also based on IP protocols.

**IMPORTANCE**

8. IMS is potentially the base of a new telecom business model for both fixed and mobile networks and is a key enabler of fixed/mobile convergence. In principle it replaces the traditional walled-garden approach of a single operator, offering a limited range of services from within a highly controlled network, with an almost limitless range of highly functional services that span multiple operator and service-provider domains fixed and mobile.

9. Obviously, technical potential and industry politics frequently collide, and IMS is not necessarily going to create an open-service Nirvana overnight. During the standard’s development there was a strong desire to perpetuate the mobile walled-garden approach, while allowing third-party developers to contribute applications and application segments. 3GPP was very anxious for mobile service providers not to end up as bit-pipe suppliers.

10. Nevertheless, it’s the fixed and mobile aspect that has got many in the industry so excited. A virtuous circle has emerged in which developments that began in the wireline environment with IP and SIP were picked up by 3G standards developers, refined and extended, and now are being fed back to the wireline community. IMS may have been designed for 3G, but now it’s much more than that, and everyone is converging on the same basic platform IMS.

**KEY ATTRACTIONS OF IMS ARE:**

(a) **Access independence**: IMS will eventually work with any network (fixed or mobile) with packet-switching functions, such as CDMA2000, GPRS, UMTS, and WLAN. Open interfaces between control and service layers allow elements and calls/sessions from different access networks to be mixed.

(b) **Different network architectures**: IMS allows operators and service providers to use different underlying network architectures. For example, access can be tightly coupled to the operator’s network or employ a third-party IP network as a looser intermediary.

(c) **Terminal and user mobility**: The mobile network provides terminal mobility, while user mobility is provided by IMS and SIP.

(d) **Extensive IP-based services**: IMS should make it easier to offer just about any IP-based service. Examples include voice over IP (VoIP), push-to-talk over cellular (POC), multiparty gaming, video/audio conferencing, and content sharing.
THE STATE OF STANDARDS

11. IMS belongs to an ongoing suite of 3GPP standards for 3G mobile networks that began with Release 99 in 2000 and saw Release 4 in 2001 and Release 5 in 2004. IMS is specified for implementation in Release 5, and the basic architecture is described in 3GPP TS 23.002, which introduces the key CSCF concept. However, Release 5 is not yet deployed in 3G networks, and IMS-enabled applications, such as POC, are being deployed in pre-R5 networks based, for example, on R99.

12. The standards continue to evolve, and the architecture reached Version 6.6.0 in December 2004. This version is not approved by the 3GPP, and so is not for implementation rather, it is to aid future development of IMS within 3GPP. Release 6, when finally approved, will significantly extend IMS capabilities, making it easier to deploy complex real-time applications. It also separates IMS from the switching core, making it genuinely access independent and specifically allowing interworking with WLAN and similar access technologies.

13. IMS has also been adopted for use in 3G CDMA networks by the 3rd Generation Partnership Project 2 (3GPP2), but renamed as the Multimedia Domain (MMD). So services based on IMS will interoperate across UMTS and CDMA 3G networks.

14. European Telecommunications Standards Institute (ETSI) and the International Telecommunication Union (ITU) are now looking to create, among other things, versions of the services provided by a 3GPP IMS core, but extended and adapted to allow delivery to fixed-line terminals, and to enable the partial or complete replacement of the existing core infrastructure supporting these terminals.

15. Most current (early 2005) IMS services are trials, but wider commercial deployment is likely in 2005. Commercial launches are mostly focused on a single application, especially push-to-talk and video sharing. Most implementations are through a single vendor, although they often involve multiple partnerships, for example for SIP servers, media gateways, media servers, and so on.

IMS ANATOMY

16. The basic idea is that IMS carries signaling and bearer traffic over the IP layer and operates as a "routing engine" or "session control" application that matches user profiles with appropriate call/session-handling servers, and then routes the call or session to the appropriate destination. The architecture includes the capability to add, modify, or delete sessions during an existing multimedia session or circuit-switched call. This opens possibilities of "blended" services that involve simultaneous voice, data, and multimedia sessions.

17. 3GPP TS 23.002 V6.6.0 (2004-12), the most recent technical specification for the 3GPP network architecture, defines IMS as comprising all the core-network elements providing IP multimedia services (such as audio, video, text, chat, etc., and combinations of them) over the packet-switched domain of the core network. The overall network architecture behind this definition has two parts an access network and a core network. In mobile terms, the access network provides the wireless access
points and links to the user, and the core network provides service control and the fixed connectivity to other access points, to other fixed networks, and to service resources, such as databases, interactive announcements, and content delivery.

Figure 3: IMS Elements

18. The core network is assumed also to have two parts, known as domains a circuit switched domain and a packet switched domain. Circuit switched connections require dedicated network resources to be allocated during a connection the PSTN is the classic example of a circuit-switched network. Packet-switched connections do not require such dedicated resources, as information is broken down into separate short messages (packets), which are routed independently through the network to their destinations, where they are reassembled into the original information streams. The Internet is the classic example of a packet-switched network. These elements are logical functions, not specific devices, and vendors are free to implement the functions as they see fit. The elements are therefore very abstract and involve a lot of obscure acronyms. IMS contains eight basic core-network elements in the packet-switched domain, shown in Figure 1.

(a) Call Session Control Function (CSCF): The CSCF can act as Proxy CSCF (P-CSCF), Serving CSCF (S-CSCF), or Interrogating CSCF (I-CSCF). The CSCF serves as a centralized routing engine, policy manager, and policy enforcement point to facilitate the delivery of multiple real-time applications using IP transport. It is application-aware and uses dynamic session information to manage network resources (feature servers, media gateways, and edge devices) and to provide advance allocation of these resources depending on the application and user context. The P-CSCF is the first contact point within the IMS for the subscriber. It accepts requests and serves them internally or forwards them. I-CSCF is the contact point within an operator's network for all connections destined for a user of that network, or for a roaming user currently located within that network's service area. There may be multiple I-CSCFs within an operator's network. The S-CSCF is responsible for identifying the user's service privileges,
selecting access to the home network application server, and providing access to that server.

(b) **Media Gateway Control Function (MGCF):** Communicates with CSCF and controls the connections for media channels in an IMS-MGW. The MGCF performs protocol conversion between ISUP and the IMS call-control protocols.

(c) **IP Multimedia Subsystem – Media Gateway Function (IMS–MGW):** May terminate bearer channels from a switched circuit network and media streams from a packet network. The IMS-MGW may support media conversion, bearer control, and payload processing (for example, codec, echo canceller, or Conference Bridge).

(d) **Multimedia Resource Function Controller (MRFC):** Controls the media stream resources in the MRFP. The MRFC interprets information coming from an AS (Application Server) and S-CSCF and controls the MRFP accordingly. It also generates CDRs.

(e) **Multimedia Resource Function Processor (MRFP):** Provides a wide range of functions for multimedia resources, including provision of resources to be controlled by the MRFC, mixing of incoming media streams, sourcing media streams (for multimedia announcements), and processing of media streams.

(f) **Subscription Locator Function (SLF):** Locates the database containing subscriber data in response to queries from the I-CSCF or AS.

(g) **Breakout Gateway Control Function (BGCF):** Controls the transfer of calls to and from the PSTN.

(h) **Application Server (AS):** Provides value-added IP multimedia services resides in the user’s home network or in a third-party location. The AS can provide Service Capability Interaction Manager (SCIM) functions to manage interactions.

19. There are other essential elements to a complete architecture that either span the core-network circuit-switched and packet-switched domains, or are essential to the mobile system. These include:

(a) **Home Subscriber Server (HSS):** Includes the Home Location Register (HLR) and the Authentication Center (AuC).

(b) **Signaling Gateway Function (SGF):** Provides signaling conversion (in both directions) between SS7 and IP networks.

(c) **Policy Decision Function (PDF):** Controls traffic entering the packet-switched network by allocating or denying IP bearer resources.

20. Looked at functionally, IMS uses a layered architecture (shown in Figure 4) and comprises a set of interfaces, SIP proxies and servers (such as media servers), and
media gateways (for connections to non-IP networks such as the circuit core or the PSTN). A key feature of the layered approach is that call and session control in IMS are independent of the service layer and access network. The strength of this architecture is that it extends the IP network from user equipment, through the control layers, to the service or called party, while remaining independent of the type of access network. So it works both with legacy networks and new access networks.

**ISSUES WITH TECHNOLOGY**

21. It’s worth pointing out that there are actually two SIPs – the Internet Engineering Task Force (IETF) SIP and the NGN/3GPP SIP. And these currently lack interoperability. Although this is an obstacle to practical NGN implementations, there are technologies that will address it, such as Session Border Controllers in the VoIP environment.

22. Some aspects of IMS are still not really properly defined for example, the MRFP (Multimedia Resource Function Processor). This was specified some years ago by the 3GPP to use H.248 (or Megaco) because that was what was available and implementable at the time. So the IMS MRFP has a pretty limited set of functionality announcements, IVR, simple conferencing, and the like and is missing the fancier capabilities, like rich conferencing, text to speech, and video, which carriers need for enhanced services.

23. However, since then, SIP has become the dominant media server control protocol in wireline NGN networks, partly because it is better for use by application servers for providing enhanced services. So it seems possible that wireline networks’ preference for SIP media servers will carry over into wireless networks, resulting in a divergence between the IMS specification and the market’s preference.
24. There are also issues over the Service Capability Interaction Manager (SCIM) function, as this acronym hides a potentially complex task, and the IMS specifications are still very skeletal here. The SCIM is going to have to play a key role in some quite complex service packages and in their associated service interactions that carriers will devise to meet the needs of different market segments. Although the CSCF provides the primary call control function, the wider tasks of service orchestration and managing integration among legacy applications and services for a better view of the IT and application environment will fall on the SCIM. So much more work needs to be done on the SCIM.

25. QoS is also a bit of an unknown when it comes to offering complex services that may involve fixed, mobile, legacy, and NGN carriers all on one call. NexTone, for example, argues that the underlying NGN transport layer (basically MPLS/IP) is going to have to become more "session aware," so that it can dynamically determine what applications or services the user is requesting and whether the network transport and network resources are sufficient to service a call. Currently, the company says, the MPLS QoS mechanisms are really aimed at bulk traffic and do not give the fine granularity needed to handle individual calls.

26. Billing and charging are going to need a lot of coordination and development in a converged multi services network and environment. Charging orchestration is talked about within the 3GPP specifications to coordinate and manage the CDRs that are created in multiple different places in the network, but there are all sorts of potential complications. For example, in a converged IP/IMS network it is not strictly necessary to charge separately for content and transport, and therefore generate two separate billing records, since the content of IP packets can be known and charged accordingly in a single environment. So there is a real need, to do the job properly, to have some sophisticated level of charging orchestration to manage and coordinate the CDRs and pass them through to the billing system to provide a flexible method of billing and charging.

WHAT DOES IMS MEAN FOR LEGACY CIRCUIT-SWITCHED NETWORKS?

27. From the IP/IMS viewpoint, many (if not most) existing networks use legacy technologies such as TDM and ATM circuit-switching with user devices that are certainly not IMS-enabled. Although IMS works with circuit-switched networks, its whole point of sophisticated multimedia services is directed towards packet networks and user devices.

28. Such a massive legacy base creates a headache for a telco’s IMS business case in today’s strict financial environment, because it makes an NGN overlay rollout in incremental stages not very appealing. Telecommunications need to boost their overall ARPU’s significantly and quickly, not just those of the relatively small number of customers that would be using IMS-enabled services under an NGN incremental overlay. Because these networks (both fixed and mobile) are big, with large numbers of customers, this means finding some way of offering at least some of these services to the many non-IMS customers from the beginning.
Fortunately, the high capabilities of IMS offer a potential solution to this problem by supporting an interim stage with an applications layer that can translate at least some of the advanced services offered to the NGN packet users into forms that can be delivered to users of legacy networks, such as the PSTN of PLMN.

Thus media servers could interwork with the PSTN/PLMN by providing a telephone user interface in place of 3G-handset GUIs or Web GUIs. For example, this interface would use text-to-speech translation (and conversely) and Interactive Voice Response (IVR) to replace some point-and-click operations. Another possibility to ease the business case is to turn the legacy network to advantage by giving the NGN access to existing, well established, enhanced services (such as local number portability and 800 service), rather than recreating these services all over again for the new network. This can be done by using SIP/SS7 gateways in the signaling layer to transfer information between the two domains without having to transfer the calls themselves.

But telecommunications also need to think about IMS in the context of a full-scale, carrier-class VoIP service and all this implies from day one. For example, the IMS-like subsystem must be able to support emergency services. Such requirements may be a tricky proposition for a technology that is not yet proven to provide equivalent levels of service to the existing circuit network, so the transition of mass-market voice service to IMS is likely to be a long-term proposition.

**IMS USES**

The whole point of IMS is applications and services, and IMS is intended to provide an environment in which it is easier, faster, and cheaper to develop and offer applications and services. It does this through a set of standard devices, interfaces, and elements from which to build such applications and services. Further, rich and dynamic combinations are possible, as IMS allows telecommunications and service providers to add, modify, or delete sessions or services during a multimedia session or call, and to combine circuit-switched and packet-switched services in the same session. And they can differentiate and bill for a wide range of services and service elements and create new sources of revenue. Some of the obvious possibilities are

(a) Presence  
(b) Push-to services, such as push-to-talk, push-to-view, push-to-video  
(c) Rich calls, such as combining video and data  
(d) Group chat  
(e) Multimedia advertising  
(f) Instant messaging  
(g) Unified messaging  
(h) Multiparty gaming  
(j) Personal information services, such as calendars and alerts  
(k) Video streaming
33. The environment at the moment is particularly excited about the potential of presence, push-to-talk, and video sharing. However, IMS proponents are keen to emphasize that it is not just a matter of entirely new applications and services, as IMS can offer existing applications, such as telephony, but with additional features and capabilities to increase differentiation, usage, and revenues.

34. A key point also is that IMS will allow telecommunications and service providers to pick and mix applications to create tailored services for specific customers and industries. An example is the management of major construction sites, where the prime contractor may be employing a large and varying number of subcontractors over the different phases of the project.

35. So the one organization could allow the site engineer, say, to rapidly create and tear down closed user groups (CUGs) of different subcontractors who may be on different networks to manage a small group of people working on specific tasks. These CUGs could be coupled with push-to-talk and push-to-see (via videophones), so that the site engineer could quickly see what a new problem was. Presence would show who was on site and available to fix the problem quickly if necessary, and location capabilities would track the plant and equipment needed. Tying these capabilities into backend systems integration would allow the site engineer to raise immediately any authorizations needed all through a mobile phone.

WHO WOULD DEPLOY IMS?

36. In principle, IMS should appeal to carriers, telecommunications, and service providers of all types, wireline and wireless, because it addresses so many of the fundamental issues facing the telecommunications industry as IP, broadband, and mobility redefine what telecom is about.

37. One can deploy SIP-based infrastructure for unicast IP telephony services into a target architecture that would harmonize on the use of SIP for all types of sessions, including IP telephony, multimedia, video-on-demand, and multicast video.

38. A big attraction of IMS for virtually all kinds of carrier is that it gives application flexibility and a way of diversifying their service portfolios, building larger customer bases, and avoiding the most dreaded of all fates becoming just bit-pipe providers. It’s a key to extracting further value from the network.

39. Mobile operators perhaps have the easiest route into IMS because they can use it in a fairly simple way at first to support a handful of key mobile capabilities, such as IM and presence management, that they know they must have. And since other desirable services, such as POC, are becoming available in IMS form, it seems sensible to start installing IMS-compliant systems, rather than proprietary ones.

40. Large telecommunications are probably the players with the most at stake over IMS simply because their networks and user bases are so big, and IMS improves their
ability to manage these assets and to extract and retain value from them. In particular, telecommunications with both wireline and wireless networks are a big target for IMS because it allows them to converge the two into a cohesive single network over which they can deliver, in principle, any real-time application.

41. It also allows them to do almost the exact opposite, and to split their networks open in very interesting ways. So a carrier could support multiple Mobile Virtual Network Operator (MVNOs), for example, by opening its control layer to their third-party applications layers. Or the carrier could host the MVNO application servers within its own service-layer facilities.

42. But IMS will also significantly sharpen the competitive threat to large telecommunications because it will enable service providers of all types, even those without networks, to offer services that may be a closer fit to the needs of the telecommunications’ own customers. Telecommunications are really going to have to understand the business models and the areas of the communications they work in if they are to retain business in a converged service environment.

**Acronyms**

3GPP: 3G Partnership Project  
AS: Application Server  
BGCF: Breakout Gateway Control Function  
CDMA: Code Division Multiple Access  
CS: Circuit Switched  
CSCF: Call Session Control Function  
CUG: Closed User Group  
DSL: Digital Subscriber Line  
GPRS: General Packet Radio Service  
GSM: Global System for Mobile communications  
GUI: Graphical User Interface  
HSS: Home Subscriber Server  
IETF: Internet Engineering Task Force  
IMS: IP Multimedia Subsystem  
IMS-MGW: IP Multimedia Subsystem – Media Gateway Function  
IP: Internet Protocol  
ISP: Internet Service Provider  
IVR: Interactive Voice Response  
LAN: Local Area Network  
MAC: Medium Access Protocol  
MGCF: Media Gateway Control Function  
MRFC: Multimedia Resource Function Controller  
MRFP: Multimedia Resource Function Processor  
MS: Mobile Station  
MVNO: Mobile Virtual Network Operator
PDF: Policy Decision Function
POC: Push-to-talk Over Cellular
PS: Packet Switched
PLMN: Public Land Mobile Network
PSTN: Public Switched Telephone Network
QOS: Quality of Service
RAN: Radio Access Network
SGF: Signaling Gateway Function
SIM: Subscriber Identity Module
SIP: Session Initiation Protocol
SLP: Subscription Locator Function
UE: User Equipment
UMTS: Universal Mobile Telecommunications System
VOIP: Voice Over IP
WLAN: Wireless Local Area Network