IMS multi-access (IMA) gives non-IMS-capable devices access to the IMS core network and services. It thus enables operators to provide IMS to the billions of GSM and ISDN terminals that are already in operation. IMA plays a pivotal role in concentrating service control in the IMS network regardless of access network and in providing consistent user experience to IMS subscribers via multiple terminals.

Premise of IMS: multi-access, single-core

The IP Multimedia Subsystem (IMS) is positioned to serve as the core network for the foreseeable future. As such, it will facilitate various forms of communication, including voice, video, messaging, and chat. These communication services will be available through a plethora of access networks. Example wireline access methods include Ethernet, cable and DSL; these, in turn, may be combined with WLAN. Wireless access networks include UMTS, HSPA and LTE.

SIP (session initiation protocol) and SDP (session description protocol) are the main signaling protocols in IMS networks. Therefore, devices that use IMS communication services must support these protocols. Media transport, on the other hand, is based on the real-time transport protocol (RTP) and the message session relay protocol (MSRP), among others. Accordingly, devices that make direct use of IMS communication services must also support these protocols.

During a period of transition, which varies from operator to operator, the IMS network will have to serve both IMS and non-IMS terminals. This is because a great deal of access networks – in particular, mobile access networks – are not yet IMS-capable for mass voice usage. Moreover, the majority of devices currently in the market are not IMS-capable. And although HSPA is a powerful enabler of mobile IMS, widespread HSPA coverage may yet take a couple of years. In the meantime, operators want to benefit from the power and flexibility of the IMS network but without the requirement to upgrade many millions of terminals. In due course, all terminals and access networks will be IMS-capable. But until that time, there will be a mix of IMS-capable and non-IMS-capable terminals.

Given the variety of access networks in operation (some IMS-capable, others not), mobile terminals will support two or more access technologies to allow operation in different environments. A prominent example today is a dual-mode phone that supports GSM and WLAN, where the WLAN side transports SIP and RTP for access to the IMS network.

Despite the use of different terminals and access networks, all call cases have one aspect in common: the IMS core network. IMS multi-access (IMA) is a pre-standardized solution for IMS centralized services (ICS) which facilitates the connection, to a single IMS network, of different terminals and access networks that are otherwise unable to transport SIP and RTP. In other words, it gives operators a way of offering consistent services to non-IMS-capable terminals. In particular, IMA addresses the billions of GSM and ISDN terminals that are already in operation. IMA is also architecturally aligned with IMS-based Voice Call Continuity (VCC, discussed below).

IMS network architecture revisited

IMS, introduced in 3GPP Rel-5, has been built around a collection of core components with distinctive functionality (Figure 1). SIP, which is the main traffic-control protocol in IMS, was developed by the Internet Engineering Task Force (IETF) and adopted by 3GPP for IMS. A quick look under the hood shows that IMS applies many proven and trusted concepts from GSM, such as the core network architecture, service triggering, and mobility.

IMS enforces strict separation between control plane and user plane. The control plane consists of network entities that are primarily involved in controlling establishment, usage, charging, and termination aspects for communication services. The user plane, by contrast, consists of network entities that process and transport media.

This separation makes it possible to
transport media between participants along an optimized path and with defined quality of service. The individual components in a communication service are made up of a mix of media – for example, voice and streaming video – and might even follow separate paths.

Unlike traditional circuit-switched networks, IMS does not establish the media path ("circuit") when a call or session is established. That is, the capacity for transporting media is not allocated until a media-transport session is actually needed and established. Therefore, media transport, which includes actions like call forwarding and call transfer, can be optimized for an established call.

Apart from supporting different kinds of access networks, IMS subscriptions can span multiple devices (for example, a GSM phone and deskbound SIP phone) and multiple public user identities (such as john.smith@telia.se and +46 730312111). IMS users may thus be reached using different identities on the terminals of their choice.

The establishment of an IMS-based communication session involves the negotiation of media capabilities between the calling and called parties. In addition, these parties as well as the IMS application servers involved in an IMS-based communication session may renegotiate media capabilities or add a multimedia component at any time during a call. For example, one of the parties might decide to add streaming video to an ongoing voice call. Alternatively, a value-added service invoked via an IMS application server could

Figure 2
Representation of an IMS network with multiple access technologies. Note also access to IMS via a circuit-switched core.

Figure 3
IMS registration for non-IMS access.
initiate a change of media capabilities during the call – for instance, by downgrading video calls to voice-only calls when users approach their credit limits.

**Access network architecture**

IMS is not dependent on a specific type of access network (Figure 2). Initially, it was specified (in 3GPP Rel-5) for 3G access – that is, WCDMA radio access (UTRAN) and a GPRS core network (SGSN, GGSN). But subsequent 3GPP releases have added HSPA and LTE. And 3GPP2 specifies the use of CDMA2000 for IMS. Likewise, 3GPP and ETSI TISPAN have defined additional access methods for the IMS core network, including WLAN and Ethernet, which may be connected to a session border gateway (SBG – Ericsson’s implementation of the interconnection border control function, IBCF) through DSL and the (public) internet.

One other example of alternative access to IMS is the generic access network (GAN) or unlicensed mobile access (UMA), which forms part of 3GPP Rel-6. More particularly, UMA specifies the use of WLAN and Bluetooth for access to GSM and a GPRS core network (2G as well as 3G access). For cable networks, the Cable Labs initiative specifies how TV cable may be used for IMS access.

**Service layer**

The service layer in the IMS network is composed of SIP application servers (SIP-AS), which is to say the SIP-AS has a prominent place in the IMS architecture. Ordinarily, telephony services, such as call forwarding, call transfer, and conference calls, are realized using a SIP-AS-based service (these services may also be controlled through the IMS terminal). Similarly, Multimedia Telephony (MTTel, a subset of basic and supplementary services from ISDN, applied in the IMS network) is realized using a dedicated SIP-AS called the multimedia telephony application server (MTAS). An additional SIP-AS may be designated for Centrex services (operator-hosted PBX functionality).

**IMS multi-access**

IMS multi-access (IMA) entails coupling non-IMS access (for example, GSM) to the IMS core network and IMS services. It aligns the control of IMS calls or sessions from the SIP-AS with the terminals and access networks that are connected to the network. IMA is available as an enhancement to Ericsson’s Multimedia Telephony (IMT) offering. With it, IMT users may establish calls from, and receive calls on, a GSM phone, UMTS phone or ISDN phone. Calls to or from an IMA subscriber – for instance, an IMT subscriber using a GSM phone – are routed through IMS, which is where the users receive their services. This is commonly known as overlay. Within the IMS network, these calls can trigger IMS-based services. A group of IMT users – for instance, the employees of a given enterprise – may comprise SIP phones (WLAN or fixed) and GSM phones. What is more, any given IMT subscriber may have a wireline SIP phone and a GSM phone, in which case calls are routed to both phones simultaneously or in sequence.

**Registration**

One essential concept in IMS is registration. For subscribers to invoke services for an IMS communication session, they must be registered in an S-CSCF (serving call session control function). Also, registration is a prerequisite for delivering calls to a subscriber’s terminal (the contact address is registered in S-CSCF). Ordinarily, SIP phones initiate IMS registration on their own. But GSM phones do not. Therefore, the overlay from a GSM call to IMS cannot offer IMS services to a GSM phone in the same way as IMS services are offered to IMS-capable terminals. The solution is to add a registration function that handles IMS registration on behalf of GSM phones. The registration function, which can be realized as a stand-alone entity or can be integrated into an IMS core node or IMS service node (Figure 3), supports two modes of operation:

- It registers users based on a provision list.
- In this case, IMS registration is independent of the actual status of the GSM device (attached or detached).

- It can also synchronize the IMS registration of a GSM phone with its GSM attach state. IMS registration of a GSM phone solely occurs when the GSM phone is attached via GSM.

In both modes of operation, for any given subscriber the registration of a GSM phone in IMS is independent of the registration of a SIP phone in IMS.

**Call establishment**

Additional functionality is needed to invoke IMS services, in particular to route (overlay) a GSM call that has been established by an IMA subscriber. One option called “hot-lining” entails employing a switch-based (vendor-specific) configuration to route the call to IMS (while preserving call-related data in the call signaling). After services have been invoked in IMS, the call is routed to its destination. In a similar way, one can route
to the IMS network a terminating call that is destined for an IMA subscriber. The call may then be routed to the IMA subscriber’s GSM phone, a SIP phone, or both (parallel alerting).

One other option is to employ a CAMEL (customized applications for mobile network-enhanced logic) service to overlay the call from GSM to IMS (Figure 4). CAMEL-based IMS overlay gives a CAMEL service control (using the CAMEL application part, CAP) over call establishment in the GSM network. The CAMEL service routes the call to the IMS network and relinquishes call control to the service (this time, using the IMS protocol instead of CAP). Then, in the IMS network, the service establishes the call to its intended destination. This way, the outgoing call is still subject to IMS services, such as Centrex.

Supplementary services
IMA subscribers have their value-added services in the IMS network. Where Centrex services are concerned, this typically includes call-forwarding and call-barring services. Therefore, for IMS subscribers, these services need not be included as GSM supplementary services. Other GSM supplementary services, such as call hold and call transfer (commonly known as mid-call services), should still be executed in the GSM network, among other reasons, thanks to the well-defined, standardized, and widely supported man-machine interface for these services on GSM terminals. This is essentially the concept of GSM-assisted services (GAS): apart from the call-forwarding and call-barring services, IMA subscribers have supplementary services provisioned in both the GSM and IMS networks. Therefore, they can use these services regardless of access method used for the call.

To execute mid-call services in IMS, an IMA subscriber might, as an intermediate solution, use dual-tone multi frequency (DTMF) tones to signal to the IMS service that call hold or call transfer is required. However, this might result in inferior user experience.

The IMS Centralized Services (ICS) work item in 3GPP Rel-8 is standardizing many of the capabilities of IMA as well as adding new functionalities. ICS is standardized in two flavors, one device-centric and one network-centric. Among other things, the network-centric and the device-centric ICS tackle the issue of mid call supplementary services. In essence, means are being standardized that make it possible to centralize mid-call services in IMS, provided ICS-specific enhancements have been deployed.

In the network-centric solution, a mobile switching center (MSC) that has been enhanced for ICS converts signaling used for invoking and executing supplementary services between GSM access signaling (the direct transfer application part, DTAP) and SIP. Preferably, the device will support Ut for user administration of supplementary services (Note: The Ut reference point is defined between an IMS terminal and user service management system in the IMS service layer). Otherwise, the operator may support user administration via other suitable means from the device, for example, using a web page.

If the device does not support any of these methods, an MSC that has been enhanced for ICS may also be called on to translate between DTAP and Ut (for user administration of supplementary services). This way, all supplementary services can be executed in IMS and administered from GSM and IMS. The execution of supplementary services in IMS is similar to the execution of value-added services in IMS. This is especially relevant for IMT subscribers who have a GSM phone and a SIP phone. By concentrating service execution in IMS, one can guarantee service consistency across a variety of devices and access networks.
The evolving network

Although IMA has been designed to support any type of GSM terminal, it can benefit from additional functionality on a mobile phone. Below we describe three recent developments in GSM/UMTS terminal functionality: dual-mode handsets, voice call continuity (VCC), and combinational services. Overlay routing to IMS is necessary for each of these features. The essential network support for these features will be realized by evolving the IMA architecture.

Dual-mode handsets
A dual-mode handset that supports GSM and WLAN can establish calls through GSM or WLAN. In the case of SIP over WLAN, the man-machine interface will hide the dual radio access capability from users. The phone may be configured to prioritize WLAN access networks for establishing calls. Likewise, the IMS core network may be configured to prioritize WLAN access networks for delivering calls to a dual-mode phone.

To guarantee a consistent user experience, regardless of whether calls are established through GSM or through SIP over WLAN, one must concentrate service execution in IMS. Calls to or from the GSM radio part in the phone are overlayed to IMS using IMA. This is handled by means of service domain selection (SDS) as specified by 3GPP. SDS employs a CAMEL service to assert the routing overlay to IMS. According to the current 3GPP specification, SDS is a static service. Therefore, SDS routes all calls to or from a dual-mode phone to IMS. However, an operator may extend SDS — for instance, with a policy that solely allows certain calls to be overlayed to IMS. When a user with a dual-mode phone is roaming in a foreign country, for example, the operator policy might require calls from dual-mode subscribers to remain in the GSM network (to avoid the cost of the international traffic link to the IMS network in the user’s home country).

Access domain selection (ADS), which is a technique for selecting the access over which a call is to be routed, is used for delivering calls to subscribers with a dual-mode handset. ADS resides in an application server in the IMS network. In order to invoke ADS, terminating calls for subscribers with dual-mode handsets must be routed to IMS.

ADS applies further intelligence to determine which access networks may be used for a call. It also keeps track of available access networks, terminal capabilities, and the access network currently in use. For each terminating call, ADS might determine, ad hoc, which access networks are available for the subscriber. If, for example, a multimedia call has been established, ADS might determine that the call can be offered through WLAN access but not through GSM.

Voice call continuity
If radio conditions deteriorate for an IMS-over-WLAN call, the handset can initiate a transfer to GSM access. Unlike unlicensed mobile access (UMA), the voice call continuity (VCC) procedure when changing from WLAN to GSM entails a change of radio access and signaling protocol. Accordingly, a terminal that changes from WLAN access to GSM access during a call, changes from SIP + RTP to DTAP/ISUP + AMR/TDM.

VCC was initially positioned as a means of expediting the rollout of IMS with VoIP capable access networks, such as WLAN. This means employees can use WLAN for mobile access to a public or corporate Centrex service (mobile switchboard). When leaving office premises, handsets initiate a transfer to GSM or UMTS access without losing voice service (Figure 5).

VCC comprises domain transfer functionality. In particular, calls to or from a VCC handset are anchored in IMS — that is, the domain transfer service functions as the anchor point for the call. When the access domain is transferred, a new access leg is connected to the same anchor point so that the rest of the call in the IMS network is not affected. VCC is deployed as a service in the IMS network.

The domain selection and overlay routing functions of VCC are identical to those for IMA — accordingly, IMA may be upgraded to VCC.

Calls to or from subscribers over GSM are anchored in IMS in order to facilitate a subsequent transfer to IMS over WLAN. Also, for IMS to manage and invoke services for calls to or from a subscriber, the subscribers must be registered in IMS. The IMS registration applied by IMA may also be applied for VCC. It should be noted that the combination of IMS centralized services with IMS-based service continuity have been standardized as multimedia session continuity (MMSC) in 3GPP Rel 8.

Combinational services
Combination services for IMS (CSI, 3GPP Rel-7) are circuit-switched (CS) voice calls augmented with IMS-based multimedia components using packet-switched (PS) transport technology. One example of a combinational service — Video Share, as specified by the GSM association — allows for streaming video between the participants of a voice call. In this context, IMS is an add-on to (not a replacement of) a circuit-switched voice call. To work, the handsets must support simultaneous circuit-switched and packet-switched access. This is standard capability of UMTS phones. To work with 2G phones, the phones and the radio access network must have dual-access mode (DTM) capability.

Call establishment between an IMS user and a CSI user requires special interworking functionality. For the CSI user, there will be a circuit-switched voice call and an IMS multimedia session. The CSI application on the terminal correlates the circuit-switched and packet-switched sessions, presenting the two as one combined call. For the IMS user, voice and video are two separate media components (two RTP streams) in one SIP session.

The CSI and IMS calls are interconnected with an IMS-based service that resides at the border between the access network and the core network of the CSI subscriber. The IMS service splits the voice and IMS data streams from the IMS multimedia session and delivers them to the CSI terminal via separate access channels (Figure 6).

• the voice component is delivered via GSM circuit-switched call access; and
• the multimedia component is delivered via a GPRS data connection.

The CSI interworking service, which resides at the edge of the IMS core network, is tasked with adapting media and signaling between IMS core network and non-IMS access networks. As described above, this adaptation requires anchoring in the IMS network. This

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aspect of CSI interworking gives substance to the strategy of combining CSI interworking with IMA and VCC. The combination of IMA, VCC and CSI may form a multi-capability access-adaptation function.

Other services in the IMS network, apart from the CSI interworking service itself, should not be affected by the media-splitting action performed by the CSI interworking service.

**Conclusion**

IMS multi-access (IMA) facilitates non-IMS access (for example, GSM access) to the IMS core network and IMS services. It is a first step toward all-IP/IMS, enabling operators to provide services like Centrex for wireline devices (for instance, office-bound SIP phones) as well as wireless devices (for instance, GSM phones) without the requirement to deploy new terminals. IMA gives operators a way of providing IMS services for non-IMS phones. One essential capability of IMA, namely anchoring in IMS, lays the groundwork for evolving toward dual-mode phone support, voice call continuity (VCC) and combinational services.

IMA plays a pivotal role in
- concentrating service control in the IMS network regardless of access network; and
- providing consistent user experience to IMS subscribers via multiple terminals, including IMS terminals, non-IMS terminals and multi-mode terminals.

The related capabilities of IMA, VCC and CSI give rise to a strategy for combining them into an integrated multi-access solution for IMS subscribers. This, in turn, sets the stage for further evolution of IMA toward 3GPP-compliant IMS centralized services and multimedia service continuity (MMSC).