

IMS for Enterprises

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ABSTRACT

We discuss how the IMS architecture is applicable to the enterprise environment, the relevance it has for enterprise users, different options for integrating private and public IMS infrastructures, and the impact of those options on enterprises and IMS service providers. Similarly, we review IMS architecture, discuss the requirements of enterprise communications systems, and present four possible architectures for the use of IMS by enterprises. We also discuss the possibility of using the service oriented architecture (SOA) to integrate IMS-based enterprise communications systems within enterprise information technology (IT) infrastructure. We have built a softswitch prototype based on the IMS architecture. We describe the implementation and the lessons we learned from this experience.

INTRODUCTION

The 3GPP-defined IP multimedia subsystem (IMS) [1] is rapidly becoming the de facto standard for real-time multimedia communications services. IMS standards define open interfaces for session management, access control, mobility management, service control, and billing. This enables service providers to offer Session Initiation Protocol (SIP) [2] communication services with more features and more flexibility than the circuit-switched network services.

Although IMS was originally specified for third-generation mobile networks, it later was adopted by other standards bodies including the European Telecommunications Standards Institute (ETSI), Telecoms and Internet Converged Services and Protocols for Advanced Networks (TISPAN) [3] for fixed networks, and PacketCable for cable-based communications systems. The common point between these bodies is that they are carrier-focused and that they target individual subscribers. The enterprise market, however, has not been addressed by these standards.

Enterprises are an important part of the potential IMS market and have some particular requirements that are not the same as those of individual users. In this article, we discuss how the IMS architecture applies to enterprise requirements, and we present four possible architectures for the use of IMS by enterprises. We discuss how the IMS architecture can be used to build enterprise communications sys-

tems, and how enterprises can be served by IMS service providers. We also discuss how to integrate IMS-based enterprise communication systems with other IT systems.

The remainder of the article is organized as follows. First, we review IMS architecture. We then discuss the potential benefits of IMS for enterprises. The article describes the four architectures for the use of IMS by enterprises and discusses the integration of enterprise communications systems within enterprise IT infrastructure. Next, we describe the implementation of an IMS-based enterprise system and discuss the lessons we learned from this experience. We then conclude the article.

OVERVIEW OF IMS ARCHITECTURE

Figure 1 depicts the main functional blocks and interfaces of IMS architecture. At the core of the architecture is the call-session control function (CSCF). This function is handled by three SIP signaling servers: the proxy CSCF (P-CSCF), the interrogating CSCF (I-CSCF), and the serving CSCF (S-CSCF). (The P-CSCF and I-CSCF are not shown in Fig. 1 for legibility.) The P-CSCF is a SIP proxy that is the first point of contact for the IMS terminal. IMS terminals discover their corresponding P-CSCF as part of their network connectivity procedure (e.g., through Dynamic Host Configuration Protocol, known as DHCP). The P-CSCF sits on the path of all of the signaling messages of the IMS terminal, ensures that SIP registration is passed to the correct home network (i.e., the administrative IMS domain to which the subscriber belongs), and that SIP session messages are passed to the correct S-CSCF after registration occurs.

The I-CSCF is a SIP proxy located at the edge of an administrative IMS domain. Its IP address is published in the DNS server of the domain, so that remote servers (e.g., a P-CSCF in a visited domain or a S-CSCF in another domain) can find it and use it as an entry point for all SIP transactions to this domain. It queries the home subscriber server (HSS) using the DIAMETER-based [4] *Cx* and *Dx* interfaces to retrieve user location information.

The S-CSCF is the central node of the signaling plane. It holds the function that registers users and connects them to services. It performs SIP request routing, provides billing information to mediation systems, maintains session timers, and interrogates the HSS to retrieve authoriza-

tion, service triggering information, and user profiles.

The HSS is the master user database; it supports the IMS network entities that are actually handling the calls/sessions. It contains the subscription-related (i.e., user profiles), authentication, and authorization information of the users. A subscriber location function (SLF) is required when multiple HSS are used. Both the HSS and the SLF implement the DIAMETER protocol (Cx, Dx, and Sh interfaces).

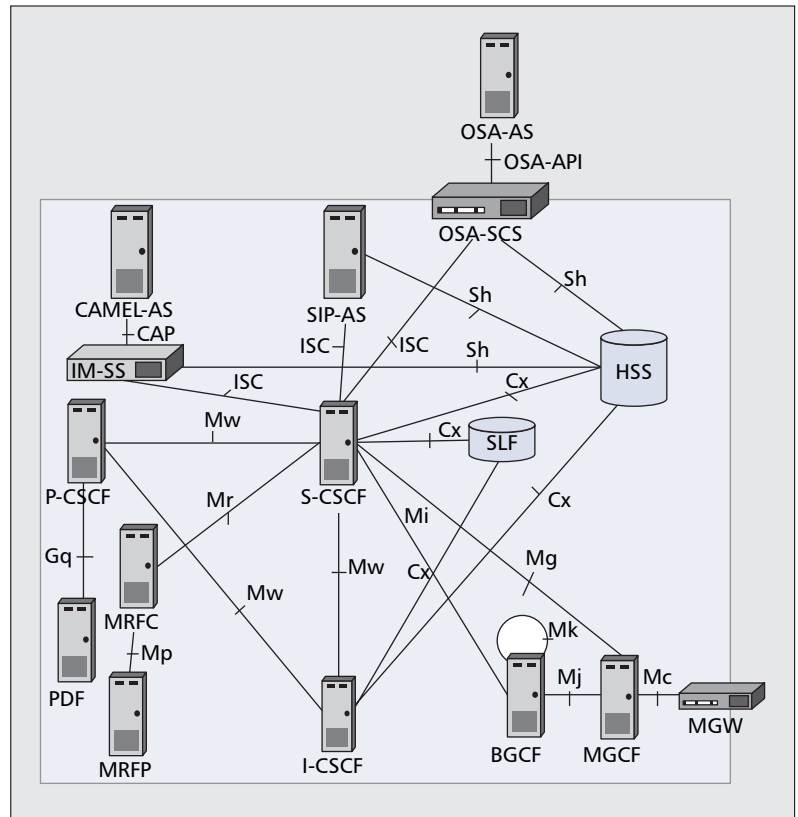
The logic of IMS value-added services (e.g., call-waiting, audio announcement, and conference) is defined and executed in the application servers. The architecture defines three types of application servers: SIP application server, open services architecture (OSA) application server, and a customized application mobile-enhanced logic (CAMEL) service environment. SIP application servers run the core network value-added services, OSA application servers run external IMS services, and the CAMEL service environment runs the legacy global system for mobile communication (GSM) services. As shown in Fig. 1, the SIP application server is directly connected to the S-CSCF. The OSA application server is connected to the S-CSCF through the OSA service capabilities server (SCS), and the CAMEL service environment is connected to the S-CSCF through the IP multimedia service-switching function (IM-SSF). The SCS and the IM-SSF are two gateways that translate the IP multimedia subsystem service control (ISC) messages (SIP messages with some 3GPP-related extensions) into OSA API (also called Parlay) calls and CAMEL application part (CAP) protocol messages, respectively.

User authentication in IMS is based on the IMS subscriber identity module (ISIM) application on a UMTS integrated circuit card (UICC) embedded in the terminal. It re-uses the UMTS authentication and key agreement (AKA) mechanism, which allows authentication and key agreement via a common secret shared between the subscriber (ISIM application) and the network. At IMS registration, the user is authenticated using a SIP digest AKA message exchange.

TISPAN has adopted the 3GPP authentication approach. This solution assumes the use of an ISIM application on a UICC that is embedded either in the TISPAN terminal, in the TISPAN residential gateway, or in a split terminal that performs the actual authentication. TISPAN has also specified another IMS access mechanism that is bundled with the network attachment authentication. This second solution requires a trust relationship between access and IMS providers.

POTENTIAL BENEFITS OF IMS FOR ENTERPRISE

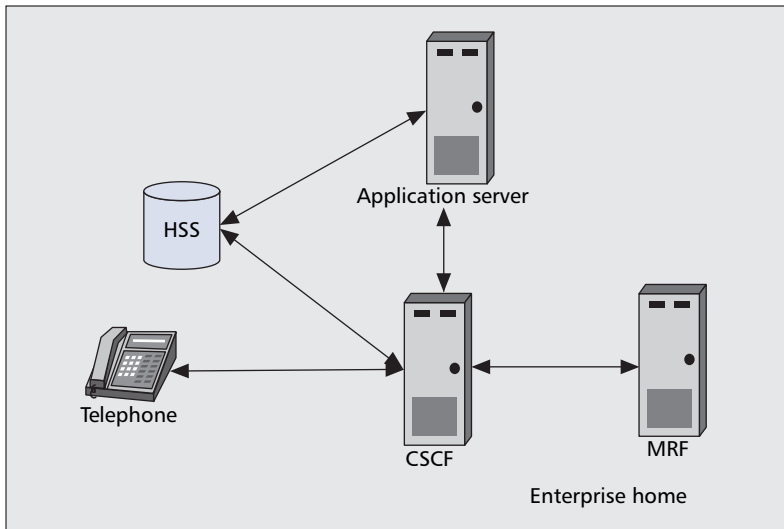
After introducing the IMS architecture, we now address the question of the relevance of IMS for enterprises. Actually, most of the services that IMS promises (e.g., telephony, IM, video) are already offered by available SIP-based softswitches. So, what would IMS provide enterprises that current systems cannot provide?



■ Figure 1. IMS functional architecture.

For enterprises, we believe that interest in IMS stems more from its framework for service delivery than from the services themselves. We must look beyond services to identify the added value of IMS. The following points summarize the framework-related features of IMS that are absent in current SIP-based softswitches and that offer potential benefits for enterprises:

- **Mobility and roaming:** IMS promises to provide access to a user's specific set of services, independent of location and serving operator.
- **Seamless roaming:** a foundation for seamless service delivery — across locations, networks, and platforms.
- **Modular architecture:** as IMS is highly modular, it becomes possible for enterprises to integrate different components or modules from different solution providers into the same system. This establishes vendor-independence and optimizes investment.
- **AAA and user discrimination:** IMS authentication, authorization, and accounting (AAA) mechanisms and HSS-based user profile management offer a large range of ways to administer service offerings per user, group of users, and communities.
- **Custom service development:** IMS application servers provide a flexible way to build new services on top of the common signaling infrastructure.
- **Universal unique framework:** IMS promises to be the unique platform of the future for the deployment of new, media-based, inter-



■ **Figure 2.** A standalone IMS-based enterprise communication system.

active, or broadcast services to the general public. Enterprises must be part of the trend.

- **Extra features:** IMS has integrated quality of service (QoS) and security mechanisms.

All these elements make it important for enterprises to benefit from IMS and have motivated us to address the question of IMS use by enterprises in this article.

IMS FOR ENTERPRISES: THE ALTERNATIVES

After stating the potential benefits of IMS for enterprises, we now address the question of how enterprises can use or benefit from IMS. IMS architecture was designed with a focus on individual subscribers, so how can IMS services be provided to enterprises (as entities and not as individual users)?

In the following subsections, we present four scenarios for the use of IMS by enterprises. For each scenario, we describe the architecture, discuss the related issues, and focus mainly on how user mobility is provided (or can be provided). We consider mobile (on the move) users, nomadic (remote locations) users, and teleworkers (from home).

A STANDALONE IMS-BASED ENTERPRISE COMMUNICATIONS SYSTEM

The first approach for IMS adoption by enterprises is to use the IMS architecture to build standalone communication systems. Figure 2 shows a simplified IMS-based architecture suitable for enterprises.

Architecture — In this architecture, all the call/session control functions are handled by the same component, called CSCF in Fig. 2. CSCF is the collocation [also referred to as co-location] of the I-CSCF, the P-CSCF, and the S-CSCF. The media functions are handled by the media resource function (MRF) that ideally is a SIP media server. The application server handles the

advanced enterprise communications services such as call forwarding, follow me, and voice-mail, as well as the integration with the enterprise IT infrastructure.

Integration with the Public IMS — Using this deployment scenario, enterprise users are not *public* IMS subscribers, which means that they don't own IMS public user identities [1]. The enterprise itself, however, is one or many IMS subscribers and can be called from outside the enterprise domain using IMS public URI (i.e., the enterprise IMS appears to the public IMS as one (or several) terminal(s), identified by one (or several) IMS public user identity(ies), for example, sip:company@operator.com (or tel:+15148751266). The enterprise also can be called directly from the Internet using its domain name (e.g., sip:sales@company.com). The application server acts as a back-to-back user agent and routes the public URI either to the enterprise interactive voice response (IVR) or forwards them directly to enterprise users.

User Issues — User authentication in this scenario can be done either using ISIM on UICC or using the TISpan bundled authentication mechanism. The second approach is more likely to be used as it places less requirements on user equipment and results in a more ubiquitous and less expensive solution.

Teleworkers and nomadic users must use soft-phones or IP phones to register (SIP registration) from their current location to the CSCF using their enterprise authentication information. Of course, they require Internet access to do so.

Mobility using this deployment scenario is not straightforward. However, there still are two possible ways to enable mobile users to participate in enterprise communications. The first way is to rely on wireless Internet access technologies (e.g., WiMAX, HotSpot). As long as the users have Internet access, they can use their SIP soft-phones on their PDA or pocket PC to connect to the enterprise IMS system. The second way is to use the public 3GPP (or 2.5GPP) infrastructure data network as an Internet access medium to the enterprise IMS system. This, however, depends on the willingness of IMS service providers to allow independent SIP traffic to transit on their infrastructure.

Benefits and Drawbacks — This architecture will use a small-scale IMS implementation, with possible savings in components. For example, a unique database could be used to support the HSS and act as a repository for application server data. Likewise, the different CSCF functions can be integrated into the same component.

Moreover, compared to currently used monolithic enterprise VoIP softswitches, this architecture is more modular.

The drawback of this scenario is that employees do not really take advantage of the mobility and roaming features of the public IMS; practically, they will be connected to two different systems.

A FULLY HOSTED IMS-BASED ENTERPRISE COMMUNICATION SYSTEM

In this scenario, the enterprise communication system completely resides within the public IMS network, in a centrex-like model. We call this scenario centrex-IMS.

Principle — The centrex-IMS service providers must offer a special subscription service for enterprises. This service should enable enterprises to be reachable by one or many IMS public URI (e.g., `company@operator.com`), allow enterprise users to reach each other using extensions (e.g., `206@company.operator.com`), and allow enterprise telephony services such as call transfer, call park, and voicemail to be offered in a transparent way.

The centrex-IMS service provider can be either a public IMS provider (with individual public IMS subscribers and a wireless infrastructure) or not. In this scenario we will focus on the case where the centrex-IMS service provider is a public IMS provider. The second case will be discussed later.

Integration with the Public IMS — In this scenario, all enterprise users are public IMS subscribers (i.e., each user has one or more IMS public user identities, e.g., `user@company.operator.com` and `subscriber@operator.com`). To be reachable, they must use their IMS-compliant mobile or desk phones to register to the IMS service provider network as standard IMS subscribers. To allow enterprise users to be directly reachable by other IMS subscribers, the service provider must perform the mapping between the enterprise private numbers and the IMS public numbers (e.g., mapping between `subscriber@operator.com` and `user@company.operator.com`). Ideally, this should be done by the application server.

User Issues — User authentication can be done in an IMS-native way for user devices that have ISIM on UICC. For desk phones and other devices, either TISPAN residential gateways or TISPAN bundled authentication mechanisms can be used.

By being fully integrated into the IMS global network, support for nomadic workers, teleworkers, and mobile workers is inherent in this architecture. Mobile users connect through the home IMS service-provider network and its roaming partners, while premises-based users connect directly to a P-CSCF located in the service-provider network.

Service Issues — Enterprise users will have access to a specific set of services, overlapping, but different from that of public IMS users. This means that the authentication mechanism must activate the appropriate set of services, but also that special filtering functions are required to allow internal calls but block external ones, allow short addressing or aliases, and so on. We believe most of these functions will be handled by the application server.

Benefits and Drawbacks — This deployment scenario is especially suitable for small enterpris-

es with highly mobile workforces. It spares the company the task of managing a telephony system and provides transparent service access for enterprise users, both internally and externally, as well as for external callers.

The difficulty appears in providing integration of services. User information and database access are two examples of problematic areas, where information may have to be duplicated or remote access to corporate information supplied to support service operations in the public IMS. Specific interfaces between the operator network and the enterprise network clearly must be provided, but no standard is available to support this yet. This issue is discussed again later.

Finally, current IMS specifications do not consider enterprise communications use-case scenarios, and hence centrex-IMS service providers must define their own specifications. Even though ECMA International (formerly called the European Computer Manufacturers Association) has done some work on enterprise communications in next-generation corporate networks (NGCN) [5, 6], its work is focused only on identifying the requirements that must be met but does not specify how requirements should be met.

ENTERPRISE-BASED APPLICATION SERVER

This scenario presents an intermediate situation between the previous two extremes. In this case, the IMS service provider is in charge of the signaling and media functions (i.e., CSCF and HSS functions), while the enterprise is in charge of the application.

Architecture — In this scenario, the enterprise maintains its own application server (AS) while still relying on an IMS service provider for the CSCF, HSS, and MRF functions. This architecture can be implemented in two ways: either the enterprise AS is a SIP AS, as defined in the IMS specifications, and hence it is directly connected to the service provider S-CSCF, or it is an OSA AS and hence is connected to the provider network using the OSA API (Parlay [7]). In the second case, the enterprise will be seen by the IMS service provider as a simple third-party applications provider. Figure 3 shows the two cases of this deployment scenario (the broken arrows are used to show the second scenario).

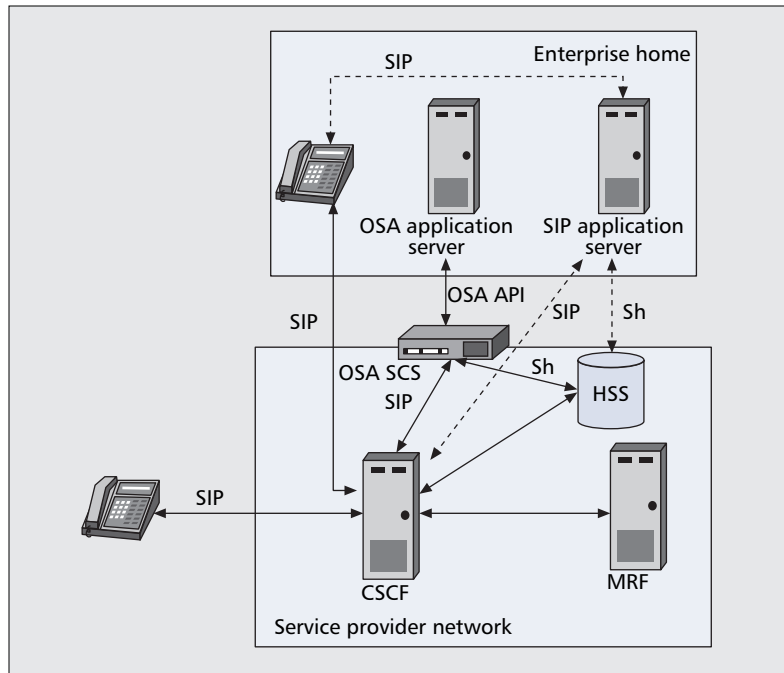
Integration with the Public IMS — In this scenario, enterprise users are regular IMS public subscribers, except that all their incoming or outgoing calls must pass through the enterprise AS. Since the S-CSCF refers SIP messages to a sequence of AS (based on the HSS profile), the service provider can easily refer the enterprise calls to the enterprise AS.

User Issues — In this scenario, the support of nomadic workers, teleworkers, and mobile workers also is inherent as enterprise users are also public IMS subscribers. Authentication also is performed in the IMS native way.

Service Issues — This model imposes a separation of service offerings. Enterprise services are separate from public services, and all enterprise users are served by the enterprise AS.

User authentication can be done in an IMS-native way for user devices that have ISIM on UICC. For desk phones and other devices, either TISPAN residential gateways or TISPAN bundled authentication mechanisms can be used.

THE ENTERPRISE AS A VIRTUAL NETWORK OPERATOR



■ **Figure 3.** Enterprise-based application server.

Benefits and Drawbacks — This architecture, like the centrex-IMS model, benefits from transparency and universal access to all employees. The advantage of this architecture over centrex architecture can be seen from two perspectives. From the IMS service provider's point of view, this architecture avoids any special processing for enterprise users: they are IMS subscribers with specific HSS profiles pointing to a particular AS. From the point of view of the enterprise, this architecture gives better control of company communications: it allows independence from the service logic and rules of the IMS service provider. Theoretically, the enterprise can change, update, and add services without requiring the agreement of the service provider, as long as these services are supported by its own AS. But in the real world, the certification of enterprise services may be required before allowing the enterprise to deploy them, because an AS configured incorrectly could cause severe problems in the operator network (e.g., performance and security problems).

The OSA approach would be preferred by IMS service providers as it offers them more protection. Actually, using the SIP-AS approach, the enterprise must have direct access to the HSS, but IMS service providers would prefer to avoid this kind of access.

On the other hand, access to other corporate services and data is easier, which makes this scenario suitable for small to large companies.

One drawback of this architecture is that, in some call scenarios, the signaling will go from the enterprise users out into the operator network, back into the enterprise network. This introduces a useless delay and some extra bandwidth consumption. However, this is not very serious, as the media need not transit through the operator's network.

A mobile virtual network operator (MVNO) is a mobile operator that does not own a wireless network infrastructure, but resells wireless services using the network of another mobile phone operator. We believe that, with the flexibility of IMS, this concept can be adopted by large multinational enterprises that do not own a wireless infrastructure but want to completely manage their users and offer the same communication services for all the users independent of their geographic locations.

The discussion in this section also applies to centrex-IMS service providers that do not own wireless infrastructures. However, in our text, we focus on the enterprise scenario and outline the centrex-IMS service-provider-related issues when they are different.

Architecture — In this IMS deployment scenario, shown in Fig. 4, the enterprise manages its own IMS infrastructure and relies on the mobile operators for the management of the mobility and roaming complexities.

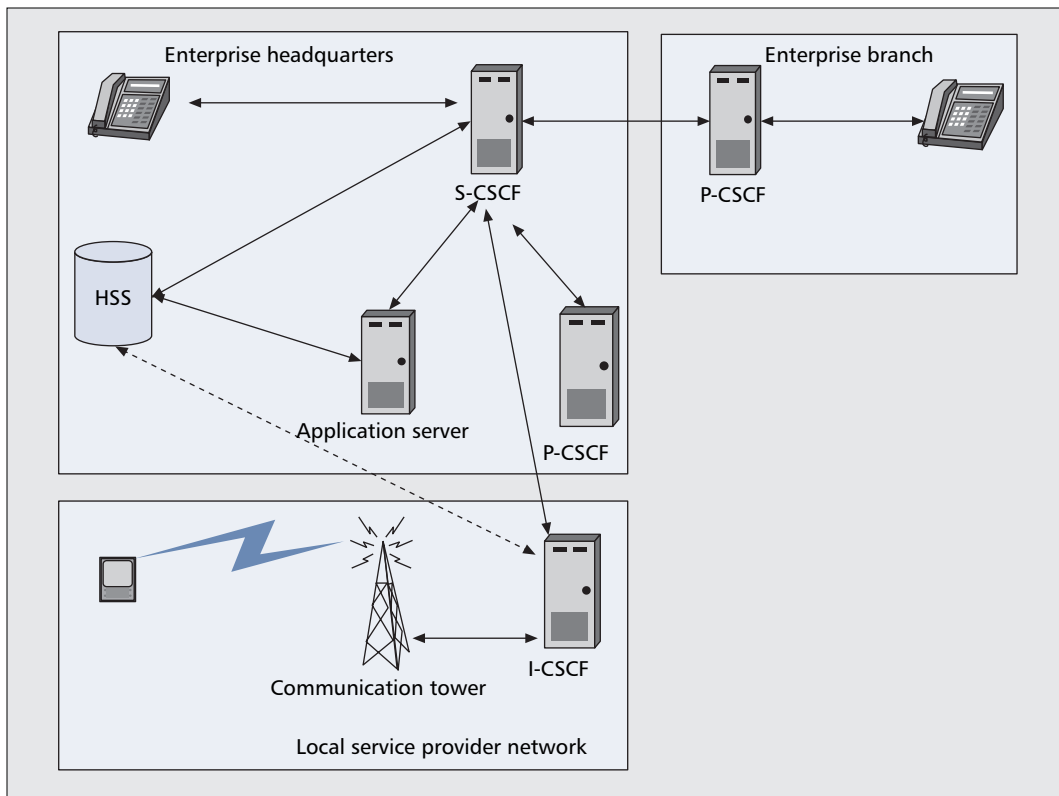
The enterprise itself maintains a HSS/CSCF (I-CSCF, P-CSCF, and S-CSCF) infrastructure. Its users have IMS public user identities (e.g., user@company.com). Its mobile service provider(s) use(s) its own I-CSCF to hand off registration of mobile users (including roamers) to the enterprise S-CSCF specified in an enterprise HSS. Users that are roaming outside the local service provider network (the provider with whom the enterprise has an agreement) are considered by the visited providers as customers of the local service provider and hence, consequently served. The service provider should use the SLF to determine the corresponding HSS of a user and have access to the enterprise HSS.

User Issues — In this scenario, the enterprise users also are IMS public subscribers, which means support for nomadic workers, teleworkers, and mobile workers, as well as authentication is provided in an IMS-native way. Here, however, the enterprise must issue its own SIM cards and establish roaming agreements.

Benefits and Drawbacks — The advantage of this approach is that it allows a large enterprise to maintain an application environment that is independent from the mobile service providers (SP). While still relying on mobile SP to manage the complexity of macro-mobility and roaming, it enables the delivery of a consistent user experience from region to region and from mobile phone to desk phone to soft-phone. Moreover, this architecture allows enterprises to have customized architectures and services that answer their requirements (which is less true for the centrex IMS service provider case as the enterprise may have no control over the AS).

IT INTEGRATION

In this section, we address an important requirement of IMS-based enterprise systems, that is, IT integration. By IT integration, we refer to the



■ Figure 4. Virtual operator.

integration of the communication system with the enterprise IT infrastructure. This requirement is not IMS related but is a new important requirement that IMS-based enterprise systems must fulfill.

OVERVIEW

The evolution of enterprise communications has been accompanied by the requirement of the integration of communication systems with the enterprise IT infrastructure. Basic forms of integration include unified messaging, which gives end users access to voice and text messaging services using the same applications (email client or telephony client) and Web-portal applications that give end users access to the corporate telephone directory. Examples of more advanced integration forms are the use of the enterprise IVR system to interact with the personal information manager (PIM) and the use of this data to control users' call flow (e.g., by diverting calls to voice mail systems when end users are unavailable based on their PIM information).

Enterprise communication systems also may benefit from being integrated with enterprise business applications. An example of such applications is a customer relationship management application (CRM), where customers are identified by their calling numbers, and their calls are forwarded to the corresponding agent and enterprise resource planning (ERP) applications, where call data records may be required for back-office operations.

We believe that SOA, an IT integration architecture that is becoming the standard way of integrating enterprise applications, also can be

used to integrate communications systems into the enterprise IT infrastructure. In the following subsections, we first give an overview of SOA and related standards and then discuss how SOA can be used to integrate IMS enterprise systems into the IT infrastructure.

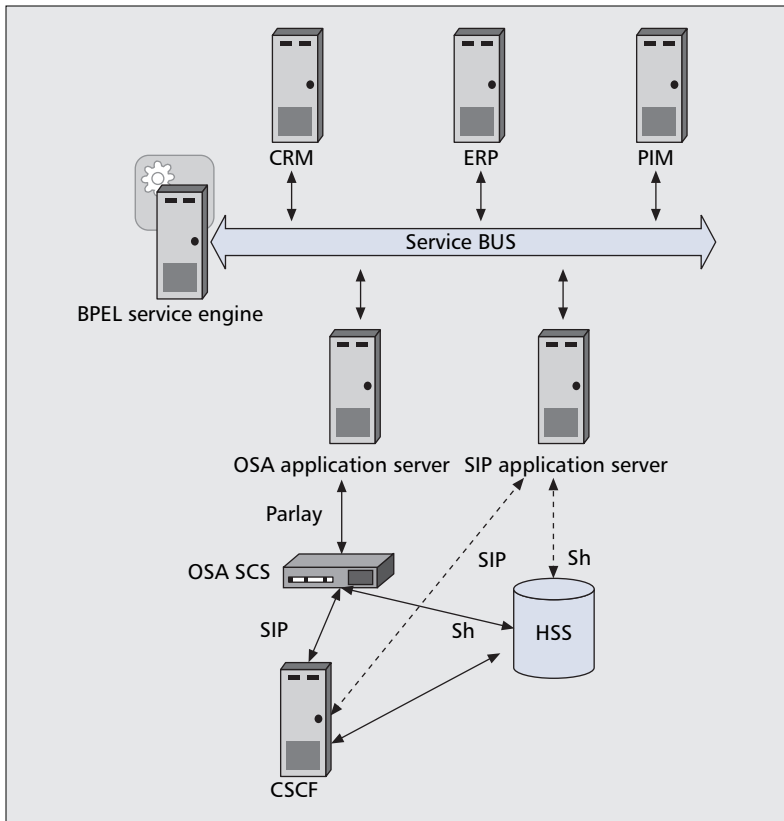
SOA AND RELATED STANDARDS

SOA is an application architecture in which applications are composed of loosely coupled services that interoperate by using standard-based interfaces. SOA services can be invoked remotely, have well-defined interfaces described in an implementation-independent manner, and are self-contained (the task of each service is specific and reusable in isolation from other services).

Although various middleware technologies have been proposed to achieve SOA, Web services standards better satisfy the universal interoperability requirements. These standards include mainly:

- Web services description language (WSDL), which is an XML language that describes the public interface of the Web services.
- Universal description, discovery, and integration (UDDI) which is a directory/registry service that manages dynamic information about service providers, service implementations, and service metadata.
- Business process execution language (BPEL), which is an XML language to model business processes and orchestrate services.
- SOAP, an HTTP-based protocol to carry requests and results of Web services invocations.

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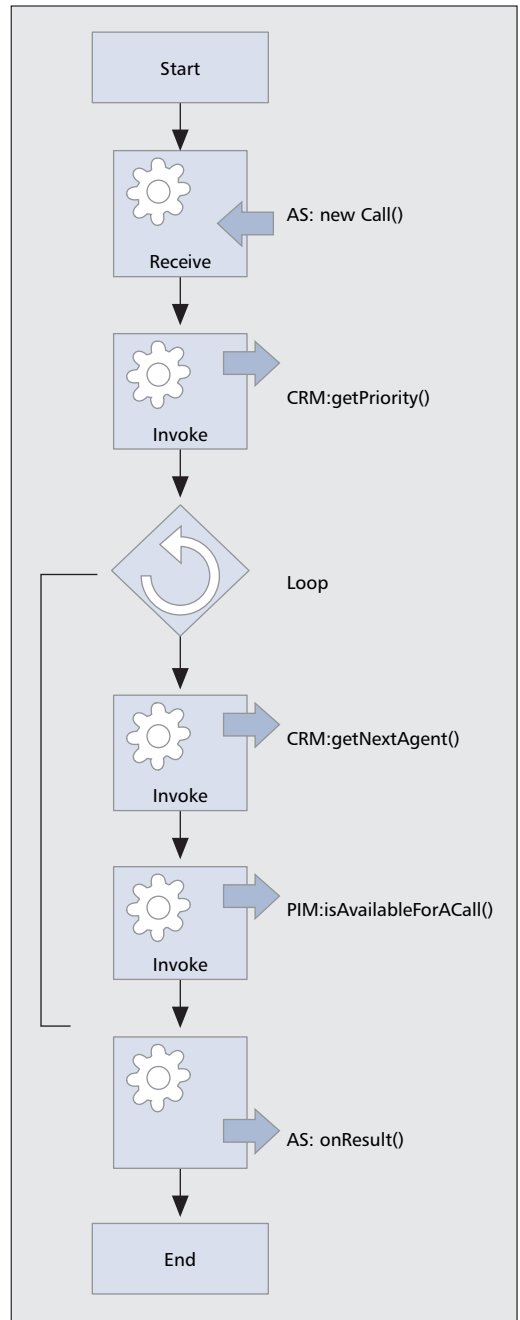
■ Figure 5. Integration architecture.

USING SOA FOR IMS-BASED ENTERPRISE COMMUNICATIONS SYSTEMS

In the four deployment scenarios described earlier, the IMS AS (either SIP-AS or OSA-AS) must take charge of the integration task. All coordination between the AS and the other IT systems must be done through Web services. The public interfaces of all systems must be Web services, and the communication between systems must be done using SOAP. Figure 5 shows the SOA integration approach. The service bus is optional middleware that provides dynamic Web services message routing and data adaptation, as well as service registration and discovery (based on UDDI). The BPEL service engine is the environment in which the BPEL scripts are hosted and executed. The BPEL service engine can run as part of the service bus (which is increasingly becoming the common approach) or as a stand-alone application. In the latter case, it will be seen by the service bus as a simple Web services consumer and provider.

The AS, whether it is SIP-based or OSA-based, must invoke the functionality of enterprise services such as CRM or PIM by calling Web services. Examples of the functionality that the AS may invoke is to check for the availability of a user (to receive a call) according to its PIM data. Similarly, the AS must expose its own functionality as Web services, so other systems can invoke them. An example of the functionality that an AS may expose is calling and playing a pre-recorded message to a user.

The complex integration processes should be



■ Figure 6. BPEL flow example.

implemented using BPEL and executed at the BPEL service engine. Figure 6 shows an example of the design of a BPEL process related to a new call that is received by the AS and behaving as follows: when a new call arrives, the AS invokes the *newCall()*¹ service of the BPEL service engine. The BPEL service engine checks the priority of the caller in the CRM, then calls the CRM again to obtain the agent who should handle the call. If this agent is not available according to his PIM data, the system will loop until finding an available agent to handle the call. The contact information of this agent is then sent back to the AS to route the call.

When the AS is owned by the enterprise, the integration depends only on the Web services capabilities of the enterprise IT systems. When

¹ For simplicity we do not show the arguments of service invocations.

the AS is owned by the IMS service provider, the integration depends on the Web services interfaces that the service provider offers. As BPEL is an XML-based, non-compiled programming language, we believe that it will be easy for enterprises to adapt their systems to meet the provider's requirements. However, the integration will be easier if the set of public Web services interfaces that IMS service providers must expose is standardized, which is not the case as of this writing.

EXPERIMENTS AND DISCUSSION

We have implemented an enterprise IMS-based VoIP system based on the stand-alone architecture discussed earlier and the SOA approach for systems integration.

In the system we have developed, the CSCF and the AS are co-located in a SIP back-to-back user agent implemented using the SIP servlet technology [8]. Collocating the CSCF and the SIP AS was motivated by the fact that transferring SIP messages through one or more signaling servers before reaching the AS adds extra complexity and cost to the solution and an extra delay to the message processing without any added functionality. We believe that, in the context of enterprises, the I-CSCF, P-CSCF, and C-CSCF functionality can be fully provided by the SIP AS without any loss of feature or functionality.

Our experience with SOA architecture was not very positive, as we discovered that most PIM servers on which enterprises rely today are not SOA-enabled. Nevertheless, we have succeeded in performing two important integration tasks. First, we integrated the voice communications system with the enterprise directory service. We have developed a Web service wrapper of the active directory API and called this service from the AS. This allows other applications to retrieve the users' telephony extensions and the AS to check the existence of an extension before trying to route the call to it. The second integration task that we succeeded in performing is to allow users to set their call forwarding preferences based on their status in their PIM server. For instance, a user can choose to forward his calls to voice mail when his calendar shows that he is in a meeting. After validating the user extension using the enterprise directory service, the AS checks the status of the user on the PIM server. Based on the result, the AS decides how to handle the call. Here also, we were required to implement our own Web service wrapper for the PIM server API.

CONCLUSION

In this article we discussed the relevance of the IMS architecture for enterprises. We presented four approaches for enterprises to use IMS. We also discussed the integration of enterprise communication systems within the enterprise IT infrastructure. We proposed the use of SOA for this purpose.

At the end of the article, we described our experience in developing an IMS-based enterprise communication system and the lessons learned from this experience. The focus of that work was to explore the issues of integration of IMS elements with enterprise IT infrastructures. It exposed the need to formalize IT interfaces in the current IMS framework and showed possible leads, compatible with current standards. More investigation of this specific issue will be required to make IMS an even more appealing proposition for enterprises.

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BIOGRAPHIES

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