Experience with an IP Multimedia System Trial for PSTN Migration

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ABSTRACT

In this article, we share our experience of a trial that attempted to gain practical experience in migrating telephony services from the public service telephone network (PSTN) to the IP multimedia system (IMS) domain. We point out some key challenges on the migration path to IMS and identify many issues for successful service deployment in an IMS-based next generation network. Some regulatory concerns and non-technical issues also are addressed.

INTRODUCTION

In recent years, worldwide telecommunications operators (telcos) have faced many challenges that severely threaten their revenue streams. For example, Skype and other free-rider peer-to-peer (P2P) applications consume most of a carrier's bandwidth and yet carriers cannot make any profit from them. Multi-service operators (MSO), on the other hand, compete aggressively with telcos in both voice and Internet access service markets by means of triple-play strategies. Carriers realize that it is important to migrate their public service telephone network (PSTN) systems into an all-IP-based network to cope with the devaluing of PSTN services. In contrast to the concept of traditional multi-platform for multi-services, an IP-based multimedia system (IMS) [1, 2] — a standardized architecture for services in the packet domain — provides *n*-play services in a single network. Therefore, IMS not only reduces an operator's costs but also enables the creation of new and rich services to increase revenues.

An IMS-based platform can provide versatile services and make use of multiple bandwidths and quality of service (QoS)-enabled transport technologies, while enabling service-related functions to be independent of underlying transport-related technologies. In addition, it enables unfettered access to networks and also supports generalized mobility that enables consistent and ubiquitous provisioning of services to the end user. Although IMS provides many benefits to users and operators, many technical and non-technical implementation issues exist. For example, regulatory environment, organization structure, system interoperability among different vendors, migration path, and profitable business models are still key challenges in moving toward IMS. As far as we know, the standards arena of next-generation networks (NGN) is highly populated and continuously evolving. This uncertainty in standards leads telcos to ponder whether the revenue derived from IMS can compensate for the huge investment and the best direction for the migration of their current systems.

In this article, we share our experiences from an IMS trial for PSTN migration. We explore the practical issues involved in a staged replacement of the PSTN network with an IMS network and obtain a practical appreciation of its implementation through understanding what the real world issues are, what the degree of maturity for the network is, and examining how IMS actually is deployed to provide new value to the end user. Some technical challenges and regulatory issues in the migration also are discussed.

IMS TRIAL FOR PSTN MIGRATION

IMS TRIAL SYSTEM

To test the maturity level of the capability of IMS to deliver on traditional PSTN services and provide new IMS services, a trial system from Ericsson was installed. The environment of the trial system is presented in Fig. 1. The trial program includes the IMS core elements as well as a video gateway (ViG) and a multipoint control unit (MCU) for video conferencing to enhance the video services provided in the trial. Multimedia on demand (MOD) as shown in Fig. 1 is a managed IP network to provide the Chunghwa Telecom IPTV service-branded MOD.

Figure 2 presents the architecture of the IMS core, consisting of a connectivity layer, a control layer, and an application layer.

- The connectivity layer provides IP access for Session Initiation Protocol (SIP) phones, plain old telephone service (POTS) access through a multi-service access node (MSAN) node, that is, multiple types of access from a single platform,

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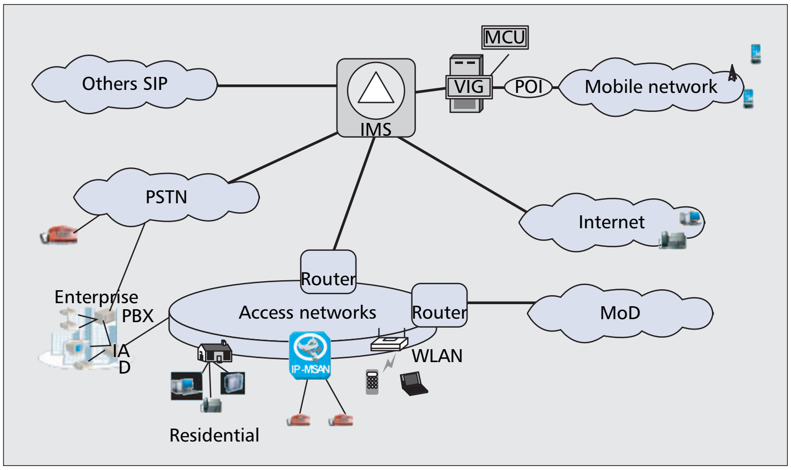


■ **Figure 1.** *Environment of the trial system.*

as well as a connection to the Internet. During the trial, access was added for wireless fidelity (WiFi), as well as integrating traditional private branch eXchange (PBX) into the centrex[1] services as part of business trunking. ENUM (which stands for electronic number mapping or tElephone NUmber Mapping systems) services were provided for E.164 to SIP address mapping.

•The control layer [3], which consists of standard IMS elements including home subscriber server (HSS), call-session control function (CSCF), access border gateway (ABG), network border gateway (NBG), and media gateway control function (MGCF) for IP telephony, as well as a media server (i.e., CS-MS, CS-CS) used for central office exchange (centrex) services.

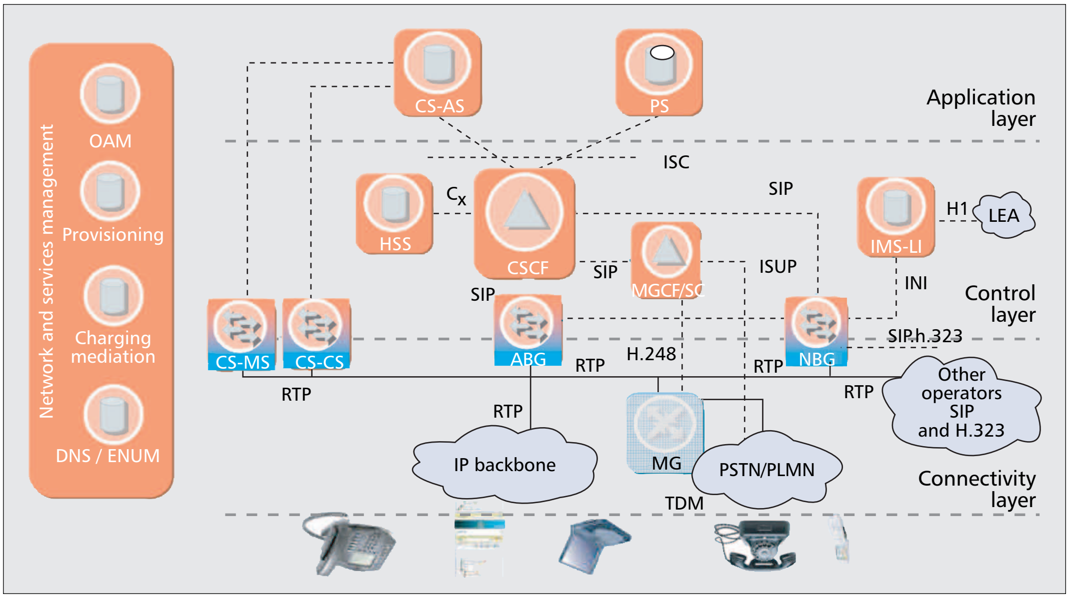
The Centrex Services-Media server (CS-MS) unit is designed for specialized media resource handling; the centrex services-conference server (CS-CS) unit handles conferencing including booking, collaboration, and bridging participants together in an audio conference. The ABG provides user-network interface (UNI) to IP access network for interoperability, security, and service assurance; and the NBG provides network-network interface (NNI) for inter-domain networking to SIP and H.323 networks. ABG and NBG also are used for lawful intercept (LI). They are provisioned with the IMS -LI node to define who is monitored. All media for calls made by these subscribers are routed to the IMS-LI node, which then routes to the law enforcement authority (LEA).

•The application layer includes application servers for providing centrex services (CS-AS), presence services (PS), and other services. The centrex services-application server (CS-AS) unit executes and manages supplementary services, IP centrex, and all the logic; the presence server (PS) unit supports presence and instant messaging services.

The IMS core also comes with complete solutions for operation, administration, and maintenance (OAM), provisioning and charging mediation. The domain name services (DNS)/ENUM server performs translations between different public entities.

Experiences of the Trial: Issues and Discussion

Testing has shown that IMS will provide all of the standard centrex services supported by advanced PBX. In addition, the IMS is easily integrated with a traditional PBX. Consider a business scenario where a company starts out with a main office with their own PBX infrastructure. As the business develops, it opens small branch offices, but the cost of buying further PBX equipment and the support personnel for these is prohibitive. The IMS solution enables the branch offices to use the IMS centrex, using either SIP-based extensions through broadband access, or analogue phones connected with a standard POTS connection. The main office continues to use the existing PBX equipment. The IMS system then seamlessly integrates all the offices, such that to the end users it appears to be a single PBX.



■ **Figure 2.** *IMS core in the trial system.*

[1] *A PBX-like service providing switching at the central office instead of at the customer's premises.*

If the PBX is non-SIP based, then the extensions of the PBX cannot register within the IMS domain, which is required for some services. To overcome this, we employ a node called a registration surrogate. This node can be configured to perform SIP registrations on behalf of nodes that are unable to do this. This functionality becomes critical for integrating legacy equipment as part of an IMS solution.

In the trial we also demonstrate how added value can be provided to the owner of an already existing PBX. By integrating a PBX into the IMS-centrex solution, functionality that a PBX lacks but is available in the IMS domain can be inherited by the PBX. Some examples of this include call center, interactive voice response (IVR) services, and music and video ring-back services (i.e., music or video played to the calling party instead of the normal ring tone). The development of new functionality of a PBX may be stopped by a vendor, yet the operator can continue to develop and provide further advanced enterprise services in the IMS domain that can be integrated and made available to existing PBX users where appropriate.

It is important that the IMS trial can demonstrate services beyond the standard speech telephony services. Here focus is placed on demonstrating video services. IMS, through its use of SIP/ Session Description Protocol (SDP) protocols, can easily perform video calls. With the addition of a ViG from Ericsson, video services can span from the IP domain across to the time-division-multiplexing (TDM) domain using 64kb/s unified display interface (UDI) bearers. This enables interworking between the IMS and 3G mobile users who have a video-enabled phone. The trial further shows the ease with which this integration took place, and how these video services can be integrated with other centrex services. Connected to the ViG is a polycom MCU for delivering video conferencing services.

When discussing new services and their implementation and deployment, it is also important to consider the areas of network management, provisioning, and charging. These areas are often considered secondary to the core network yet if these areas are not properly considered, they easily can hinder or even prevent the deployment of new services. We recognize the importance of these areas and include complete commercial systems for each of these areas as part of the trial. What is critical is the flexibility of these systems to cope with a highly dynamic environment. The intention with IMS is to have rapid service deployment — some services developed by the operator, some coming from the system vendor, and others coming from third-party developers. In this type of environment, how do you manage such a network? The operations support system (OSS) solution provides integration support for third-party products. The provisioning system allows all provision logic to be completely customized by the operator; if a product has a proprietary protocol, then this can be implemented using an open software development kit (SDK) provided as part of the solution. Charging mediation supports multiple formats and allows complete customization of the billing mediation. These solutions give complete control of customization to the operator, enabling them to be fully integrated into the operator's business systems and delivering a significant and necessary time-to-market advantage for new services.

During the trial program, an important issue was noted with SIP phones, an area that may have been overlooked by many. An analogue POTS phone requires no configuration. You plug it in, and it works. A SIP phone is not so simple. You must program various settings to achieve different levels of functionality. To register and gain access to the network, as a minimum, you must define the URL, user-id, and password for the SIP phone. To have a similar dialing style as a traditional phone, you must program a dialing plan for the handset. How many non-technical people are capable of doing this? If various settings for the phone are not configured properly, minimally this will lead to a bad experience and affect the adoption rate of new services. Network solutions are required to enable automatic configuration of the customer premises equipment (CPE) and to ensure an *out of the box* plug-and-play offering. Although setting configuration via Dynamic Host Configuration Protocol (DHCP) is a feasible solution, CPE must be customized so as to send and receive these DHCP options, such as option 60, 61, 120,125. Because we expect various kinds of CPE for IMS service in the future, CPE customization and provision system deployment will be a big challenge.

During the trial, a number of services were evaluated. Some areas, such as IP-centrex services have an immediate market within the enterprise segment. These can be bundled with user-friendly video conferencing services to form a corporate package. Yet everyone still wants to know "What is the killer application for IMS?" IMS does not offer a killer application, but rather a *killer platform*. It enables the operator to efficiently find killer applications through an environment that enables rapid prototyping and deployment of new services. Perhaps by developing 100 services, one service is found to have a popularity worthy of the title *killer application*. Another nine applications are capable of bringing in a good revenue stream, but due to being targeted at a narrow user group, they cannot be considered to have universal appeal. The other ninety services are found to be not profitable and so after a trial deployment period, they are withdrawn from service and either sent to the scrap-heap or adapted into a new variant, to then be tried on a new target group.

IMS offers a cost-effective platform that enables rapid deployment of new services in a cost-effective way. This is what allows the one hundred services to be deployed so that the ten profitable ones can be found. However, it is not just about finding those ten, but providing the killer platform that enables continuous development and continuous discovery of new profitable applications. The key characteristics of the IMS platform in comparison to softswitch-based solutions and traditional TDM solutions are listed in Table 1.

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Characteristic	IMS	Softswitch	TDM
Convergence on IP protocol	Yes	Yes	No
Standardized network architecture	Yes	No	No
Level of separation of control and application layers	High	Medium	No
Terminal mobility	Yes	Yes	No
User mobility	Yes	Yes	No
Universal connectivity	Yes	No	No

■ **Table 1.** *Comparison of different solutions.*

From PSTN to IMS Domain

Rationale of PSTV Migration

IMS brings together the required components for quick service development. But it also is poised as a PSTN replacement technology. The replacement of PSTN must provide the same service level and experience for those subscribers that are not yet ready to embrace a new technology. At the same time, the network must continually offer new services to maintain value for the users who are willing to embrace new experiences.

In migrating the network from a TDM to an IMS-based network, it is important to look at all the services supplied by the existing network and map the functionality onto the new IMS core and access network. Key services include:

- Standard speech telephony service.
- Supplementary services, such as 3-way calling, call forwarding, and so on.
- Intelligent network (IN)-enhanced services, such as toll-free service, and so on.
- All of the standard centrex services provided by advanced PBX solutions.
- Legacy access technologies, such as integrated-service digital network (ISDN) and coin-box telephone booths.
- Regulatory defined services, such as emergency services, number portability, and so on.

In general terms, most of the basic voice and supplementary services provided by a PSTN network today can be provided by IMS. These either have been standardized by Telecommunications and Internet Converged Services and Protocols for Advanced Networking (TISPAN) R1 [4] or are in the process of being standardized. However, currently, there is no planned solution for implementing ISDN services and coin-box based telephone services through IMS. To continue to support these services, other solutions are required.

Apart from the standard supplementary services, it is typical for a fixed-line operator to be offering some proprietary services provided by the vendor of the TDM switch. For these services, it is necessary to evaluate their value and the need for migration towards the IMS domain. If needed, migration can be solved through the addition or adaptation of application servers.

Steps in PSTN Migration

In planning the migration [5] of the network toward IMS, it is necessary to understand the history of the PSTN network. Since the network has typically existed for a long time, with the addition of few new services, there are telephone exchanges that are over fifteen years old. The initial part of the migration strategy is to retire the oldest exchanges and move the subscribers to the IMS domain, where they receive the same or nearly the same service level they are familiar with through a POTS access.

The migration requires the transfer of subscribers in a number of steps. The first step is a test stage, where a small number is first moved across to test the transfer procedure. After a period of stability, the remaining subscribers can be transferred either in one step or in stages, depending on logistical issues.

With the launch of the IMS domain and the start of the migration of subscribers from retired exchanges, it is possible to start promoting new service offerings available within the IMS domain. These services either can be subscribed to by the newly migrated subscribers for the relevant service fee, or a non-migrated subscriber can be migrated as a single subscriber to gain access to the new services. This requires the capability in the TDM network to route terminating traffic for this subscriber across to the IMS domain, because the numbering range in which his number belongs still resides within the TDM network.

The migration from TDM to IMS then follows two main processes. As exchanges reach the end of their useful service life, they are retired and decommissioned. The subscribers belonging to these exchanges are migrated to IMS. Subscribers that wish to have services that are only available within the IMS domain are migrated across individually. After a known period of time, all TDM exchanges are retired, with a single IMS network remaining. Some of these subscribers will choose not to move towards the new services, instead being content to continue to use a standard POTS interface. However, even with a POTS interface, a number of new services will be available. The remaining subscribers have accepted the differences associated with an IP-based interface and are making use of more advanced services. Apart from these POTS users, there also will exist some other users of the IMS network. One example is set-top boxes for IPTV services.

Now we illustrate two scenarios as follows.

- Scenario 1 — Retiring an old exchange and migrating all users to IMS.

Migrating all the subscribers will be done in stages. The first stage enables a few subscribers to be migrated for testing. Subsequent subscribers can be migrated at one time, or in stages, depending on logistical issues.

If the exchange can support re-routing of terminating traffic on a per-subscriber basis, then scenario 1a is used (Fig. 3a). The blue arrows show the original network routing for subscribers belonging to local exchange 1 (LE1). When a subscriber is migrated, a suitable subscriber service is used to force route-terminating traffic to the IMS domain. This is indicated in green. After all subscribers are migrated from LE1 to the IMS domain, the routing in the network is updated. This is indicated in red.

If the exchange is unable to re-route terminating traffic for individual subscribers (normally, only applicable for very old exchanges), then scenario 1b is used (Fig. 3b). All traffic is first routed to the IMS domain as shown in green. If the subscriber is already migrated, the called party number is mapped into a SIP address by ENUM and terminated in the IMS domain. If not yet migrated, then no mapping exists in ENUM, and the call is routed back to the LE1 exchange.

- Scenario 2 — Individual subscribers are migrated to IMS for new services.

In this scenario, the network routing strategy is the same as scenario 1a.

If the PSTN network has number portability (NP) and employs [All Call Query], that is, for every call made, the number portability database is queried, and then NP is used to determine if the subscriber has been migrated and to which domain they belong, this delivers a more efficient routing. For this, the NP database must have a new network prefix added to represent the IMS domain.

Intelligent Network (IN) Service in PSTN Migration

As part of this migration strategy, it also is important to consider the role and migration of any existing IN services within the TDM network. For each IN service, it is important first to identify its applicability to IMS. For example, a virtual-private-network solution probably can be fully provided by centrex services in the IMS domain. This would then require tuning the centrex to give the "look and feel" of the TDM-based solution, such that end users do not sense a significant difference when migrated. For something such as prepaid services, it may be more complicated if the user is allowed to make use of other chargeable services within the IMS domain, as the TDM solution would not be designed to handle this.

Depending on the situation for each service, a number of scenarios can be considered.

- Use the existing service control point (SCP). This is suitable when the service logic is applicable to the IMS domain without adaptations and the service usage is low. The call is either routed back to the TDM domain to trigger the service, or it is accessed from the IMS domain via a conversion between SIP and intelligent network application part (INAP) signaling. Many SCP vendors supply products for their SCP to perform this conversion.
- Migrate the service to an IMS application server. In many cases, it is found that the service logic in the SCP cannot be applied to the IMS domain. The effort to adapt the SCP service to the IMS domain is comparable to migrating the service to an IMS application server. With the network efficiencies this offers, the decision normally is to migrate the service.

Issues about Regulatory Services

Apart from subscriber services, there are regulatory services, normally mandated by the government, that state what all telecommunications providers within a country must provide. These include such services as: emergency services, number portability, equal access, and lawful intercept. These are critical services to implement. Without a proper implementation, it can be impossible to get government approval to launch the new IMS network. For emergency services, the main focus is how to obtain the correct location information such that emergency calls can be routed to the nearest emergency call-handling center. This is accomplished by obtaining location information from the access network as part of the subscriber registration procedures. In replacing a subscriber's POTS connection with a broadband connection, lifeline service (i.e., service availability during a blackout) becomes difficult to provide. Power-over-Ethernet (PoE) does not provide the required distance. Providing a powered twisted pair would require the powering of the xDSL modem and SIP phone. This issue appears to lack a mature solution today, with some operators opting to initially provide broadband access as a second line, thus avoiding this regulatory issue until suitable solutions are available.

Number portability normally is deployed as an IN solution and so should be considered as part of the IN migration [6] strategy. Equal access can be implemented trivially as an application within the IMS domain. For lawful intercept, it will be important to offer solutions that target not just speech, but also video, presence, and instant messaging. The challenge for lawful intercept in the future seems to be even greater, as the potential for specialized applications with specialized protocols comes into play. As an example, consider a multi-player game that also incorporates voice communication within the game. To intercept and monitor the data is straightforward enough, as this still uses SIP/SDP. However, how do the law enforcement agencies interpret the intercepted data? This scenario becomes even more plausible in the scope of massive multi-player games, where individuals could log into such a game and go to a common location within the scope of the game world to communicate. The accessibility becomes very easy, yet how is lawful intercept applied to this on a practical basis? If these scenarios cannot be monitored and with the further popularization of these types of games, the validity of lawful intercept services is reduced.

Non-technical Issues in Migration Path

Apart from the technical issues discussed previously, equally challenging are the operator's organizational issues. Having developed over such a long period of time, the internal organizational structure of a fixed-line operator tends to be directly related to the network architecture. What does it mean when you wish to totally transform the network? How easy is it to achieve a similar change within the operator's organization? The business climate is demanding significant changes but can the organizational issues be

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This trial focused mainly on the functionality that can be delivered by an IMS network with off-the-shelf technologies. As IMS matures, it will be more important to investigate and analyze the ability of IMS to deliver advanced end-to-end services in a timely manner.

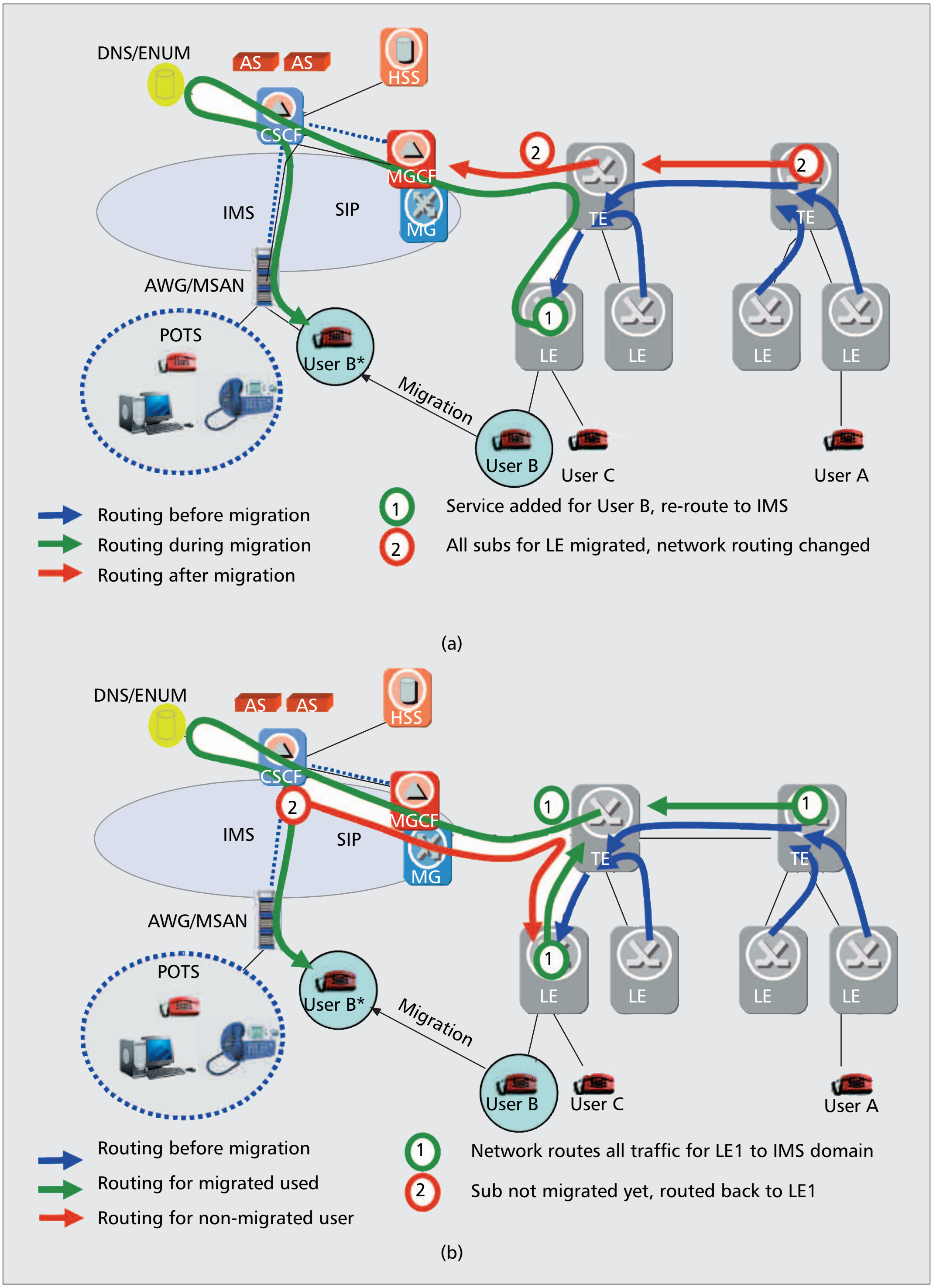

Figure 3. *Two scenarios for PSTN migration: a) scenario 1a; b) scenario 1b.*

overcome quickly enough? The change is not only in architecture, but also in technology. We are going from a world of TDM, SS7/C7 and ISDN user part (ISUP) signaling [7], to a world based upon packet technologies, IP signaling, and SIP signaling. There is a requirement for fundamental change in technical competence, from a traditional telecoms domain to something that is a hybrid of telecoms and Internet technologies. These changes take time, and so it seems reasonable that a migration of the PSTN network be executed over a staged period, allowing the organization to adjust and adapt as the migration progresses such that once the migration is completed, so is the transformation of the organization.

Conclusion

In this article, we have shared our experiences in an IMS trial based on commonality-ready components for providing carrier-grade packet voice service. In addition to voice service, the services tested in the trial included advanced IP centrex, mobile office extension, fixed-mobile convergence (FMC), and video conferencing services. We noted in the trial that although the tested IMS system offered similar services to today's PSTN, some advanced supplementary telephony features are not yet ready for service. These problems are not caused by the technical challenges but by the development schedule. Fortunately, most of these obstacles will be solved by TISPAN R2. Finally, we also showed that today's IMS is a platform for rapid new service development and deployment. In the near future, it also will be capable of PSTN migration.

IMS is still at an early stage of development, and this trial focused mainly on the functionality that can be delivered by an IMS network with off-the-shelf technologies. As IMS matures, it will be more important to investigate and analyze the ability of IMS to deliver advanced end-to-end services in a timely manner. In deploying services, one must investigate the full scope of service deployments, including system integration activities for third-party application servers, service provisioning and charging, as well as service blending. End-user services are a blended composite of services derived from different application services. It is strongly recommended that readers planning IMS trials focus on these areas. We believe that IMS will play a key role as a source of revenue and as a valuable addition to traditional PSTN operators. The significant differences between a standardized IMS network and a proprietary softswitch network will become even more apparent.

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REFERENCES

[1] G. Camarillo and M.-A. García-Martín, *The 3G IP Multimedia Subsystem (IMS): Merging the Internet and the Cellular Worlds*, Wiley, 2006.
[2] K. Knightson, N. Morita, and T. Towle. "NGN Architecture: Generic Principles, Functional Architecture, and Implementation," *IEEE Commun. Mag.*, Oct. 2005.
[3] TS 24.229, "IMS Call Control Protocol Based on SIP and SDP; Stage 3."
[4] ETSI TR 180 001 v. 1.1.1, "Telecommunications and Internet Converged Services and Protocols for Advanced Networking (TISPAN); NGN Release 1."
[5] P. Podhradsky, "Migration Scenarios and Convergence Processes Towards NGN," *Proc. 46th Int'l. Symp. Electronics in Marine*, June 2004.
[6] M. Finkelstein *et al.*, "The Future of the Intelligent Network," *IEEE Commun. Mag.*, June 2000.
[7] G. Camarillo *et al.*, "Integrated Service Digital Network (ISDN) User Part (ISUP) to Session Initiation Protocol (SIP) Mapping," IETF RFC 3398, Dec. 2002.

BIOGRAPHIES

HONG-BIN CHIOU received a B.S. degree from National Taiwan University in 1986, an M.S. degree from National Tsing Hua University in 1989, and a Ph.D. degree from National Taiwan University. In 1991 he joined Telecommunication Laboratories, Chunghwa Telecommunication Co., Ltd., Taiwan, and is involved in the research and development of multimedia communication systems. His current research areas include wireless communications, broadband networks, and network planning and management. From 1989 to 1991 he worked as a project researcher in the PC System Design Department of the R&D Division of Acer Inc.

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