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Fix-Mobile Convergence – are we ready?

LEILA LAMTI-BEN YACOUB, DIEGO DIVIANI AND ERIC DE FROMENT **European telcos are facing significant fix-mobile substitution threats asking for a clear fix-mobile convergence strategy to break up separate fix and mobile business development processes.**

We understand convergence at the service layer, i. e. allowing the combination of different wireline and wireless devices, networks and services to offer customers a seamless voice and data environment. Convergence should be perceived by residential end customers as a way to enjoy ubiquitous communication services and access their personal information, independent of the underlying network and of used end-devices.

Such new services also require convergence at the network layer. However, we are not considering here pure network optimisation without service impact. Two layers are concerned with the convergence: the SIP (Session Initiation Protocol) signalling layer being adopted by the majority of fix and mobile service providers as the signalling protocol for future IP communication and data services; and the IP layer where Internet connectivity takes place. This article aims at presenting the impact of fix–mobile convergence on the network and service layers. For each of the two layers, we analyse and evaluate in terms of advantages and drawbacks the technical options for a fix–mobile convergence implementation. Finally, we propose the first steps towards convergence based on selected implementation options to reach the above-mentioned goal.

Impact on the SIP Layer

The 3rd Generation Partnership Project (3GPP), the European Telecommunications Standards Institute (ETSI) and the Parlay Forum have defined a service architecture called IP Multimedia Subsystem (IMS), which supports the requirements of a mobile IP multimedia environment. A simplified version of IMS is shown in figure 1.

The IMS service architecture uses SIP as the signalling protocol with some extensions dealing with mobile world specificities. SIP was initially defined by the Internet Engineering Task Force (IETF) as an application layer control protocol for creating, modifying and terminating sessions in the fix Internet world. Fix incumbent operators are now in the process of deploying IETF compatible SIP solutions to implement Voice over IP (VoIP). On the other hand, mobile operators are either launching IMS trials or defining their IMS strategy. For an incumbent with both fix and mobile branches, it is now time to define a clear convergence strategy that deals with both implementations. A prerequisite would be to ensure at least SIP interoperability between fix and mobile worlds before a convergent and possibly common SIP layer can be implemented.

In order to analyse the impact of the convergence on the SIP layer, we begin with a short description of the IMS architecture. Then, for an incumbent with fix and mobile branches we propose possible SIP convergence scenarios involving IMS and IETF SIP platforms. Each scenario will be analysed and its advantages and drawbacks presented.

Overview of the IMS Architecture

The IMS architecture can support multiple application servers providing traditional telephony services and non-telephony services such as instant messaging, push-to-talk, video streaming, multimedia messaging, etc. The service architecture is a collection of logical functions which can be divided into three layers:

- *Transport and Media Gateway Layer:* It provides media gateways that are responsible for initiating and terminating SIP signalling to set up sessions and to provide bearer services such as conversion of voice.
- *Session Control Layer:* The call session control layer contains the Call Session Control Function (CSCF), which provides the registration of the endpoints and routing of the SIP signalling messages to the appropriate application server. The CSCF interworks with the access and transport layer to guarantee Quality of Service (QoS) across all services. The call session control layer includes the Home Subscriber Server (HSS) database that maintains the unique service profile for each end user.
- *Application Layer:* The application server layer contains the application servers, which provide the end customer service logic. The IMS architecture and SIP signalling are flexible enough to support a variety of telephony and non-telephony application servers. A telephony application server is a back-to-back SIP user agent that maintains the call state. It contains the basic service logic which provides the call processing services including digit analysis, routing, call setup, call waiting, call forwarding, conferencing, etc. The application layer can also contain SIP-based application servers that operate outside of the telephony call model. These application servers can interwork with endpoint clients to provide services such as Instant Messaging (IM), presence-enabled services, etc.

SIP Convergence Scenarios

Convergence assumes SIP service session mobility, i. e. the end customer has a unique service profile (one identity) and does not need to reauthenticate at the service layer when

the underlying network changes. This means that the SIP service session is not interrupted while moving from one network to another. We mainly distinguish two flavours for SIP service session mobility:
- *Seamless handover:* SIP service sessions are seamlessly handed over from a fix to a mobile network and vice versa without any noticeable impact on the delay. Such an implementation is only possible using dual-stack end-devices (fix and mobile protocol stacks), a unique and common network authentication mechanism (for example SIM-based) and IPv6 as the enabling networking layer to avoid Network Address Translation (NAT) traversal impacts on delays. Such an implementation is the most adequate for real-time convergent services, for example VoIP.
- *Session mobility:* Even if the session is not interrupted, the handover between fix and mobile networks is not necessarily short. This means that multiple network authentication (for example SIM for mobile and user name/password for fix) can still be supported. Such an implementation is suitable for non real-time services, for example instant messaging.

In both cases, SIP session mobility should be guaranteed-between the two networks. For incumbents with fix and mobile branches, we mainly distinguish three scenarios ensuring SIP session mobility:
- *Fix IETF SIP scenario:* A unique IETF compliant SIP platform is deployed for both fix and mobile services.
- *Mobile 3GPP IMS scenario:* A unique 3GPP IMS SIP is deployed for both fix and mobile services.
- *Mixed IETF-IMS scenario:* The two platforms are kept separate but interoperate to ensure SIP mobility.

In the following, we describe the three scenarios in more detail and present their advantages and drawbacks.

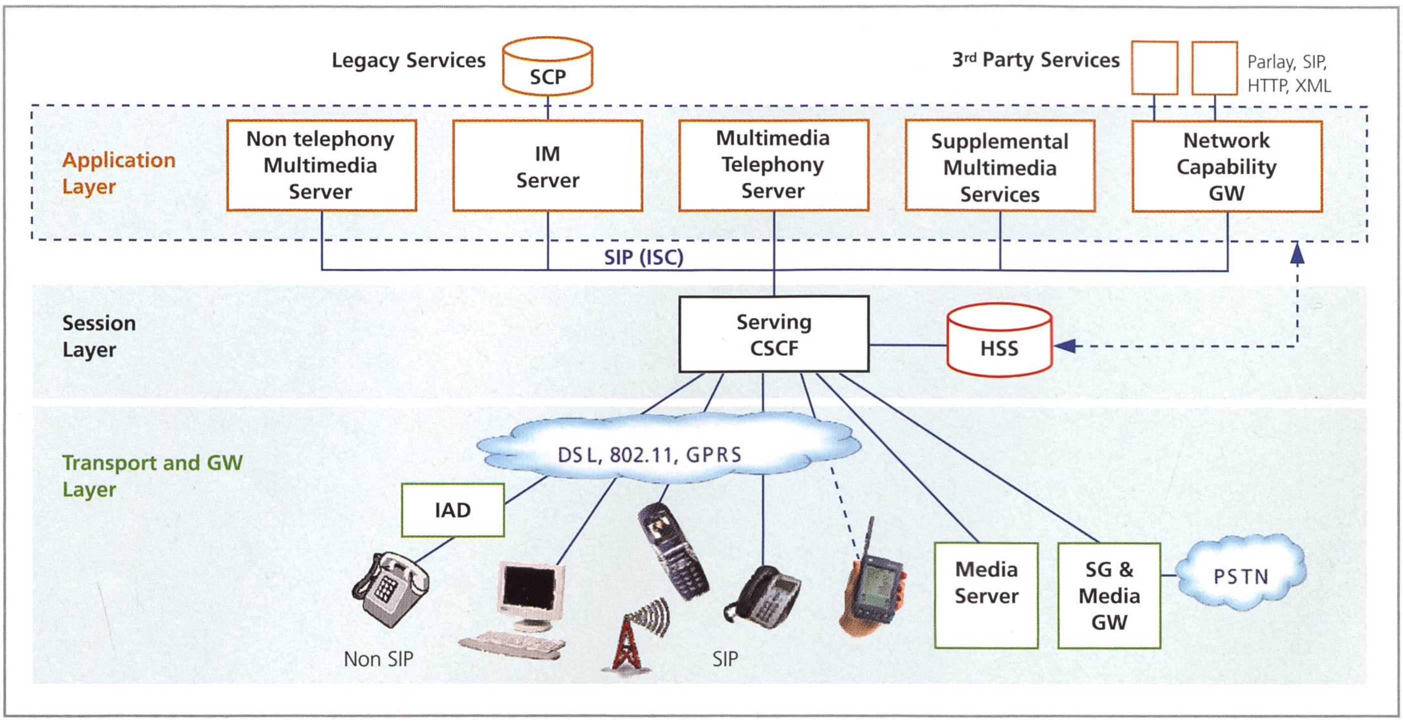
Fix IETF SIP Scenario

This scenario supposes the usage of a classical IETF SIP platform for fix and mobile services and end-devices. It is however unrealistic if no upgrades are foreseen to allow 3GPP compliancy. This is mainly due to the following reasons:
- 3GPP has defined several SIP extensions to deal with mobile network specificities. Without these extensions, an IETF SIP platform would be unable to fulfil the requirements of mobile services. The main extensions include:
  - QoS reservation and compression mechanisms to deal with the scarcity of the radio interface
  - Roaming between home and visited networks through specific SIP proxy implementations that interface with the Home Subscriber Server (HSS)
  - A sophisticated user service profile concept that uses SIM cards for authentication at the service layer and for charging purposes
  - Use of IPv6 as the underlying network protocol (even though several vendors have implemented IMS with IPv4)
  - Lawful interception
- The incumbent needs in any case to ensure interoperability and roaming with other mobile service providers which could implement 3GPP IMS.

A possible extension of this scenario is to implement a superset 3GPP/IETF SIP stack which can be used by any fix or mobile client/end-device. This requires a close collaboration with the IETF SIP vendor to implement a smooth migration of the classical IETF SIP platform into a 3GPP compliant platform.

A key advantage of this scenario is the opportunity to build new services based on the basic SIP building blocks in order to investigate the target IMS service offering, and gain feedback from real users without a heavy investment into a

Fig. 1. IP Multimedia subsystem architecture overview.



3GPP IMS compliant solution. The solution could evolve gradually to full 3GPP IMS compliance with reuse of deployed components.

A major drawback of this scenario is the risk of vendor dependency. In fact, having both fix and mobile platforms from one vendor does not allow interoperability testing, a must for an incumbent that requires roaming capabilities with other fix and mobile operators. Moreover, such an upgrade could be a long process hindering the opportunities of the mobile branch of the incumbent if 3GPP IMS compliancy becomes a must on the market.

Mobile 3GPP IMS Scenario

In this scenario one 3GPP IMS SIP platform is deployed for fix and mobile IP multimedia services. The IMS service platform is independent of access networks (GPRS, UMTS, WLAN ...) and the underlying network authentication, thus allowing seamless service convergence.

The implementation of this scenario has a major impact on end-devices. In fact, terminals require a new type of SIM module called the IMS-SIM (ISIM) and need to support an IMS SIP compliant client supporting 3GPP SIP extensions presented in the fix IETF SIP scenario.

It is important to mention that the SIM card (or the UMTS SIM card) allows identifying and authenticating end users to access 2G or 3G networks, while the ISIM is used to identify and to authenticate the end customer to access IMS enabled services.

A major advantage of this scenario is the unique investment that the incumbent needs to make in order to develop new broadband fix-mobile multimedia IP services.

A major drawback of this scenario is that in 3GPP Release 5 IMS, the ISIM module must be co-located with the UMTS SIM on the same chip card. This restriction limits the feasibility of an IMS-based solution for converged fix–mobile services. Such a scenario would be possible only if all fix and mobile end-devices supported the new chip card. As an alternative, access to the IMS domain would be possible through an implicit registration process of user identity. If this is possible, service profiles could be used through this mandatory implicit registration function for ISIM-less end-devices. Until now, no clear answer from the vendors allows guaranteeing the existence of such a solution.

3GPP Release 6 IMS provides a further step towards real convergence with complete ISIM independence of the UMTS SIM card. "Virtualised" software-based IMS SIM cards could be integrated in future fix and mobile end-devices to access IMS services.

Finally, it is worth mentioning that first full IMS capable terminals implementing ISIM and supplementary SIP extensions are expected for the end of 2005. Vendors have announced proprietary solutions providing a subset of IMS without all the decided 3GPP features for this year.

Mixed IETF-IMS Scenario

In this scenario, mobile 3GPP IMS and fix IETF SIP platforms are kept separate but interoperability is ensured on the SIP layer and could be implemented in two ways:

– *Direct interoperability:* The fix SIP server directly communicates with the mobile SIP server for signalling and for session mobility. This option seems to be unavailable now since the interface standardised by 3GPP under the name of "Mm interface" has not been tested so far. Moreover, according to the list of extensions that 3GPP has introduced on SIP for IMS, we believe that the non-interoperability risks are quite high. A major advantage of this option is its simplicity and independence of the implementations. The major drawbacks are its uncertainty and the double investments and OPEX costs.
– *Indirect interoperability:* A SIP Application Server (AS) is placed between the two SIP platforms to implement a signalling gateway function. This means that the SIP AS has on one hand an IETF SIP compliant interface and on the other hand a 3GPP IMS SIP compliant interface. It breaks each SIP session into two sessions and plays the role of a "man-in-the-middle" (fig. 2).

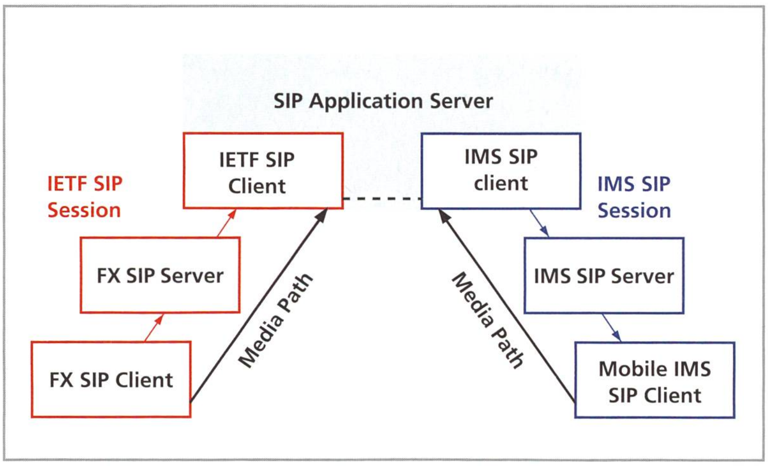


Fig. 2. Interoperability scenario where IMS and SIP platforms are kept independent and interworking is ensured by a SIP Application Server (signalling gateway).

The major advantages of this scenario are its availability on the market and the independence of the two implementations. The major drawbacks are: (1) the SIP AS would be a traffic bottleneck, (2) the complexity of the implementation and (3) the double investments and OPEX costs.

Impact on the Network Layer

Once SIP session mobility is ensured, the question arises as to the need for network layer convergence. A major issue here is network authentication. As explained above, the final goal of full convergence means handover between fix and mobile networks with end-to-end QoS. However, handover can either be seamless or noticeable, and only seamless handover, required for real-time applications, has implications on the network. Such implications can be classified into three clusters: network authentication, IPv6 and QoS.

Network Authentication

When an end-device connects to the network, it is aware of the applied authentication method. For example, a UMTS end-device connecting to the UMTS network makes use of the well-defined UMTS authentication method based on quintuplets. On the other hand, a fix end-device accessing through a DSL network or through WLAN access points may use EAP (Extensible Authentication Protocol). EAP is running in the access on top of a low layer security model called 802.1x. It can be used for both fix and wireless networks and may be adopted to support any kind of authentication method. For seamless handover between fix and mobile networks, EAP seems to be the most convenient solution on the market.

IPv6

IPv6 is an enabler for fix-mobile convergence in the sense that it eliminates the Network Address Translation (NAT) boxes and promotes end-to-end transparency. In fact, seamless and short handover could be hindered by the NAT process which must learn the new private IP addresses the end-device gets after registering on the new network.

Moreover, IPv6 implicitly integrates a mobility concept that allows a mobile end-device which is accessing through a visited network to handle the call more efficiently than with IPv4. This concept also enables an efficient bundle with security and peer-to-peer encryption.

We believe that IPv6 eases convergence because it allows the usage of multiple IP addresses on one end-device, thus facilitating network integration and convergence through soft-handover mechanisms (for example smooth redirection of a call).

Finally we should mention that ongoing work (see references, pending patent on WLAN handover) is defining a new mechanism to achieve WLAN handover using either IPv4 or IPv6.

Quality of Service

In both fix and mobile networks, end-to-end QoS was initially based on bandwidth and channel reservation. However, over-dimensioning coupled with both well-suited network engineering mechanisms and traffic prioritisation seems to offer the best combination to fulfil QoS needs of the majority of applications. Nevertheless, the radio access, be it WLAN or UMTS, is still scarce and bandwidth reservation remains a hot topic. We mainly distinguish the following activities:

- *QoS in WLAN networks:* QoS will be progressively introduced as soon as the IEEE 802.11e specifications become available. The goal is to support QoS policy enforcement tools in the WLAN access point to guarantee end-to-end QoS.
- *QoS in 3G networks:* UMTS has always implemented QoS. However, without IMS implementations QoS is not based on the service type. The introduction of IMS makes the network QoS-aware, meaning that not only the session layer is involved but also coordination between bearers and session layers, making the QoS chargeable according to the data traffic and user type. The IMS Release 5 makes the policy control for QoS tied to the IMS platform. However, in Release 6 interfaces between IMS and QoS elements are decoupled, enabling a true converged end-to-end QoS solution.

Conclusion

In this article, we have presented the impacts of fix–mobile convergence on both fix and mobile branches of an incumbent, on both the SIP and the network layers. On the SIP layer, convergence can be implemented in three ways:

- using a unique IETF SIP platform for all services of an incumbent,
- using a unique 3GPP IMS platform for all services of an incumbent,
- keeping the two platforms separate and ensuring interoperability and SIP session mobility.

Based on our analysis, we recommend focusing on the last scenario of interoperability to open the road for convergence. On the network layer, full convergence is only needed for real-time services requiring seamless and short handover. In this case, a robust and common network authentication based on the SIM card (for example EAP) coupled with IPv6 and QoS mechanisms in the network would be most suitable.

Convergence should be implemented in a stepwise manner. A convergence roadmap would be as follows:

1. Proof of concept of SIP session mobility using a convergent non real-time service on different interoperable SIP platforms (for example instant messaging or SMS/MMS interoperability). This first step will be tested at Swisscom Innovations in the coming months within the context of the ZEUS project.
2. Proof of concept of QoS mechanisms in mobile networks (3G and WLAN),
3. Proof of concept of SIM-based authentication for both fix and mobile devices,
4. Proof of concept of seamless handover (using IPv6 or IPv4),
5. IMS release 6 for all SIP-based services of the incumbent,
6. Converged service scenario. ■

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