Chapter 3

IMS (IP Multimedia Subsystem)

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Abstract. The IMS (IP Multimedia Subsystem) technology is a framework architecture for delivering IP multimedia services, which allows voice and multimedia applications to communicate from multi-access scenarios (Wireless, PacketCable, DSL, etc.), thus allowing the convergence of fixed and mobile networks. We have carried out an investigation into the current state of the art of this technology, focusing on its architecture, operating principles and especially in the current state of development in Argentina. We have also made a forecast of what will happen in the next 3 years and our vision of what today are the best practices for its implementation.

Keywords: IMS, Architecture, Services, Multimedia

1. Introduction

In this chapter, we describe the basic operation of the IMS (IP Multimedia Subsystem) architecture. To do this, we analyze the different layers of the architecture (Access, Transport, Control and Application). Then, we perform a more detailed analysis of certain features of the Transport and Application layers, such as different levels of CSCF (Call Session Control Function), the HSS (Home Subscriber Servers) and AS (Application Servers). Just as an example we introduce some flowcharts associated with a registration and a normal call, where the full operation of all previously explained components can be checked.

Then, we introduce part of the results of different opinions obtained in meetings with market specialists involved in the development of this technology. At these meetings, we discussed about the relevant issues associated with IMS, and the information we have obtained is reflected in several tables.

To complete the study, we have evaluated existing technologies at present and the degree of development of them. With the information obtained, the experiences, the meetings and the whole of the investigation, we share our vision of best practices for implementation in the medium term in Argentina.

2. IMS Architecture Overview

The IMS is an umbrella that aims to integrate all the information and communications technologies for new services that can be implemented to make full and integrated use of the existing communications services.

The idea of the architecture is to define a model that separates the offered services (voice, video and data) from the access networks used for these services (fixed telephony, cellular networks, cable companies, etc.).

Considering that the services that can be implemented are varied and open to the creativity of designers, we shall introduce a simple example for easy understanding. Suppose we are talking with out mobile phone and we are arriving to our office, which has a Wi-Fi equipment. IMS would allow our mobile phone leave the connection of the cellular network and continue it (like a normal handoff) through the Wi-Fi network. In this case, the access network would be changing.

We may also want to come to our desk (in our home or office), and continue our communication from a Soft-Phone that we have in our Tablet or from a fixed telephone line. In this case, we are changing the terminal.

The above is only a minimum example of services that can be implemented on an IMS network. We hope they were easy-to-understand examples that allow us to visualize how the access network or the terminal will be irrelevant in the future.

3. IMS Architecture

The IMS architecture is designed in a structure of levels, planes or layers, and each layer having its network elements and functionalities. The layers are described below:

3.1 Access Layer

The access layer can represent all high speed access, such as xDSL (x Digital Subscriber Line), cable networks, Wi-Fi (Wireless Fidelity), WiMAX, LTE (Long Term Evolution), among others.

3.2 Transport Layer

The transport layer represents an IP network. This network can integrate QoS (Quality of Service) mechanisms with MPLS (Multi Protocol Label Switching), DiffServ (Differentiated Services), RSVP (Resource Reservation Protocol), among many others.

The transport layer is mainly compunded by routers ("edge routers" for access and "core routers" for transit).

3.3 Control Layer

The control layer is made of several Session Controllers, which are responsible for routing signaling between users and for the invocation of the services. These nodes are called CSCF (Call Session Control Function). In this layer, we can also find the HSS (Home Subscriber Server) and the MRF (Multimedia Resource Function), which is also known as IP Media Server (IP MS). The MRF is divided into two parts, the MRFC (MRF Control), located in the control layer, and the MRFP (MRF Processor), located at the transport layer. The interconnection between MFRC and MRFP is performed via the H.248 protocol.

3.4 Application Layer

The Application Layer introduces the applications (also known as "value added services") offered to the users. Depending on the organization of the control layer of its IMS Stack, the Service Provider could offer integrated services by itself or eventually by third parties. This layer is compounded by the AS (Application Servers).

4. Competencies of Each Layer

Below is a figure where the competencies of the most important layers can be observed:

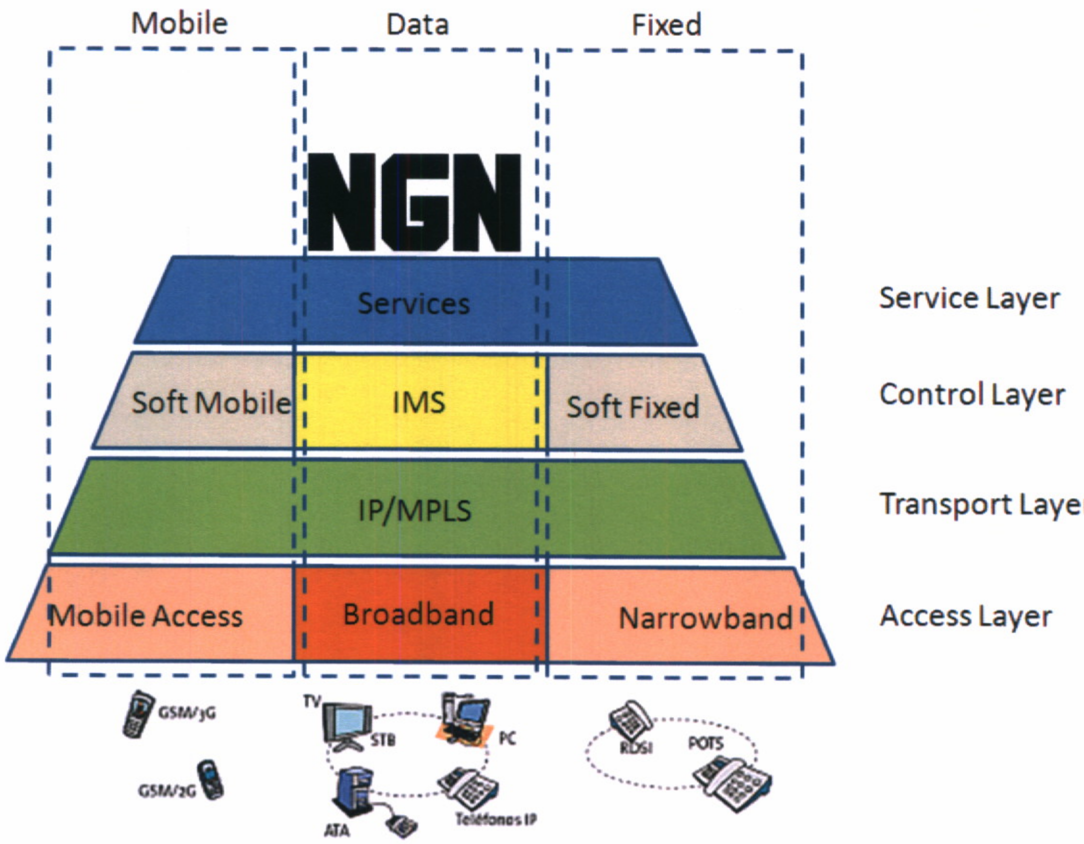

Fig. 4. IMS layered Architecture (http://sociedadinformacion.fundacion.telefonica.com).

As already mentioned, IMS means "IP Multimedia Subsystem". The term "Subsystem" is because it is not a network that replaces the existing or legacy ones. In fact, this is a subsystem that is inserted into existing networks, allowing legacy systems interoperate with the new technologies. This can be done by means of the SIP Protocol (Session Initiation Protocol) as the signaling protocol for the elements of the control layer as the base architecture.

The following figure shows a simplified IMS architecture with the blocks mentioned in the present document, with the inclusión of additional elements, such as BGCF (Breakout Gateway Control Function), MGCF (Media Gateway Control Function) and MGW (Media Gateway). These three elements are relevant for the interconnection between the IMS network with PSTN legacy networks of the same provider or external ones.

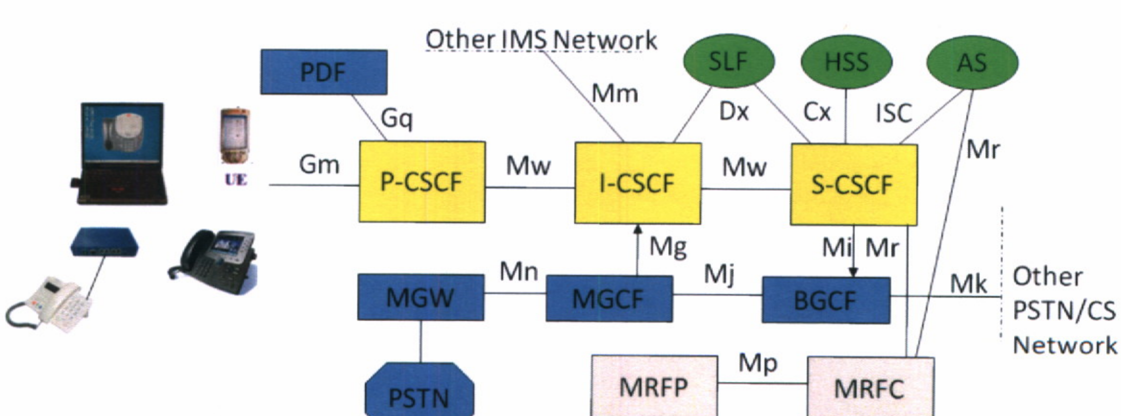

Fig. 5. Simplified IMS Architecture.

4.1 The Control Layer

As mentioned above, one of the most important elements in the IMS network control layer is the CSCF (Call Session Control Function). This network element is further subdivided into 3 components in order to distribute tasks more efficiently when working with large networks (Carriers), and separate them into different physical machines assigned to each of these tasks, and then linking them through well-defined interfaces and thus being able to operate in a multi-provider scenario.

The IMS architecture was designed to provide comprehensive and complex support to the IP multimedia services associated to a large number of users. At the same time, there can be a scalable architecture which can have any kind of traffic level. This means that the CSCF servers can be dynamically allocated to the users.

The layered structure allows separating the roles of each member of the architecture. For example, the CSCF servers mentioned above have the function of redirecting the packets that are carrying the SIP signaling to and from the terminals and applications where the services will be executed. It means that the CSCF servers do not resolve the services or standardize applications, since they (the applications) are performed in an upper layer.

In other words, a brief summary of the control layer main task is to facilitate the access of multimedia applications to different types of terminals and access technologies (fixed or mobile).

The CSCF components are P-CSCF (Proxy CSCF), S-CSCF (Serving CSCF) and I-CSCF (Interrogating CSCF).

1. P-CSCF: Is the input interface of Customer's signaling through the Core IMS. It works as an IMS SIP Proxy server for all the users. It accepts all SIP requirements originated in the terminal Equipment (or addressed to it), and processes them internally or forwards them to another server. The P-CSCF also takes care of control and resource management for all sessions created through this Server. It can be located on a local network or a visited one (in the case of mobile networks). It has an interface to the PDF (Policy Decision Function), to which provides information for the admission of the media and to implement QoS (Quality of Service) policies inside the network.

2. S-CSCF: It is the main element of any IMS network in terms of signaling. The S-CSCF is the CSCF component which is mandatory in the IMS network. The S-CSCF is the control point in the network that allows operators to control all sessions and all the services' provision. It is a SIP server that always resides in the local network of the subscriber. The S-CSCF creates a link between the public user identity (SIP Id) and the IP address of the terminal, and interacts with the customers' database (HSS - Home Subscriber Server) in order to get the user profile and authentication vectors. All SIP messages originating from the terminal or addressed to it have to go through the S-CSCF. In this element, the messages are processed and subsequent tasks are determined based on the contents of them. The S-CSCF is also responsible for allowing the user to contact the appropriate application server, and interacts with the application servers and forwards SIP messages between them. The IP address of the S-CSCF can be incorporated in the "Service Route" field of the SIP message in the registration process, and thus making posible a direct access to the S-CSCF from the P-CSCF, bypassing the I- CSCF.

3. I-CSCF: It is a Proxy SIP server that provides the link to the CSCF with external networks. This module selects an S-CSCF for a user and forwards the SIP messages between them. The selection of S-CSCF is based on required capabilities and the available ones, together with the network topology, allowing the possibility of a load balancing between S-CSCFs with the help of the HSS. If the Core will feature several HSS, the I-CSCF will need to initially contact the SLF (Subscription Locator Function) for the purpose of obtaining the address of a HSS for the subscriber.

Mentioned above several times, the IMS architecture includes other important functional entity, the HSS (Home Subscriber Server). This Server uses the "Diameter" protocol for the connection with the S-CSCF and the AP (Application Servers). If there is more than one HSS in the network, an SLF (Subscriber Location Function) can indicate the user's address to the appropriate HSS servers. The Home Subscriber Server contains subscription information associated with subscriber profiles. On the other hand, it performs user authentication and authorization, and can provide information about the subscriber's location and IP data.

All applications and services in the IMS Core are performed in SIP Application Servers.

4.2 The Application Layer

The SIP AS (Application Server) is the network element where the service logic is executed. These servers can be dedicated to a single service or even handle more than one. In the IMS Core, it is also possible to combine different Application Servers for the purpose of creating a unified end user experience. For example, a user could simultaneously combine "Presence" and "Video Call" services, although the services themselves are hosted in different SIP Application Servers. The main benefit of using Application Servers is the ease and speed with which services can be provided centrally. The centralization of services in one or a few Application Servers facilitates the processes of updating and improving services for all users, preventing problems of incompatibilities due to the management of out-of-date software releases.

It is important to mention that in the ETSI/TISPAN standard, associated to the IMS architecture for fixed networks, the HSS Server (discussed in the control layer) is also considered as a component of this layer.

5. Registration of a Typical IMS Terminal

Each step of the registration process of a SIP terminal in IMS architecture is explained below.

Part 1:

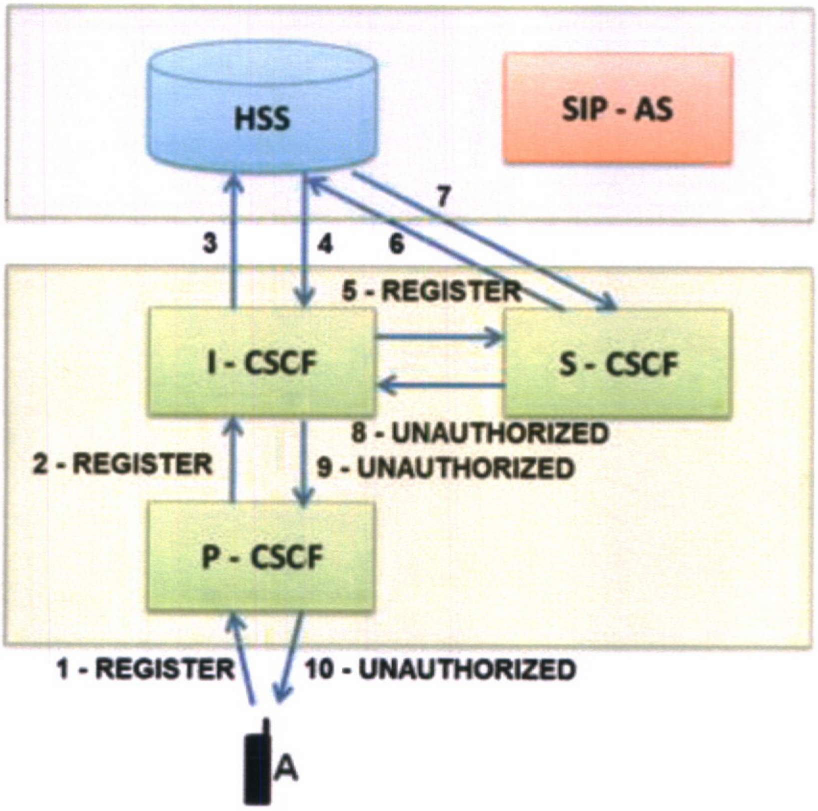

Fig. 6. IMS Registration process – Part 1

1. The UE starts with a SIP "REGISTER" request including the public and private user ID to the P-CSCF

2. The P- CSCF performs a DNS request to find the I-CSCF in the user home network. It adds a field to indicate the visited network connected at this time and forwards the SIP "REGISTER" request to the I-CSCF.

3. and 4. The I-CSCF receives the SIP "REGISTER" request and sends the Diameter UAR (User Authorization Request) to the HSS. The HSS checks that the user ID is correct and roaming agreements are

present for that user in the visited network, and sends a Diameter UAA (User Authorization Answer) back to the I-CSCF.

5. I-CSCF receives the UAA containing the S-CSCF assigned to the user. Another possibility is that it could receive the criteria for selecting one S-CSCF. In this case, the I-CSCF would select a suitable S-CSCF and would forward the registration request to this new S-CSCF.

6. and 7. S-SCSF sends a Diameter MAR (Multimedia Authorization Request) request to the HSS for downloading the authentication vectors to challenge the terminal. This request includes the address of the S-CSCF so that the HSS knew which S-CSCF is assigned to the user. The HSS sends the Diameter MAA (Multimedia Authorization Answer) response with the authentication vectors.

8, 9 and 10. The S-CSCF answers the SIP "REGISTER" request message with a SIP "401 Unauthorized" response containing the information to carry out the security challenge. This response reply goes through the I-CSCF and P-CSCF until it reaches the user.

Part 2:

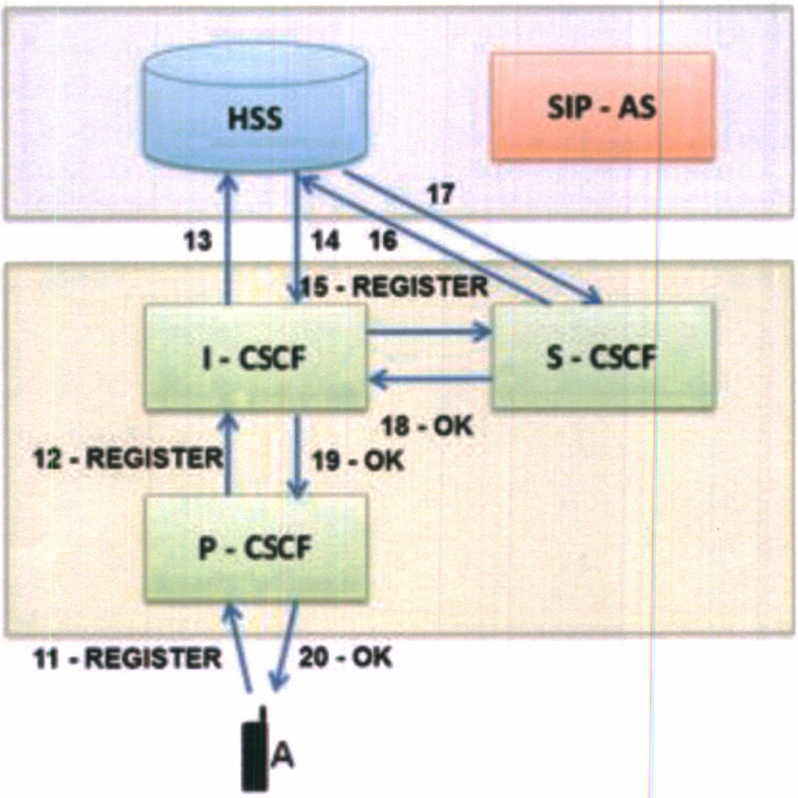

Fig. 4. IMS Registration process – Part 2

11. The user sends a new SIP REGISTER request including security challenge response and forwards it to the P-CSCF.

12, 13 and 14. This new request reaches the I-CSCF, which sends a new UAR to the HSS to find the S-CSCF, to which forwards the SIP "REGISTER" request.

15, 16 and 17. The S-CSCF receives the SIP "REGISTER" request and authenticates the user, sends a Diameter SAR (Server Assignment Request) request to the HSS to inform that the user is registered and requires downloading the user profile. This download is included in the Diameter SAA (Server Assignment Answer) response of the HSS.

18 and 19. The S-CSCF informs to the Application Servers (those contained in the user profile) about the registration that the user is performing, because it will make an impact on the services.

20, 21 and 22. The S-CSCF confirms that the user is registered by sending a SIP "200 OK" response through the I-CSCF and P-CSCF, and finally reaches the user.

6. Steps of a Basic IMS Call

We will now focus on the steps of a basic call.

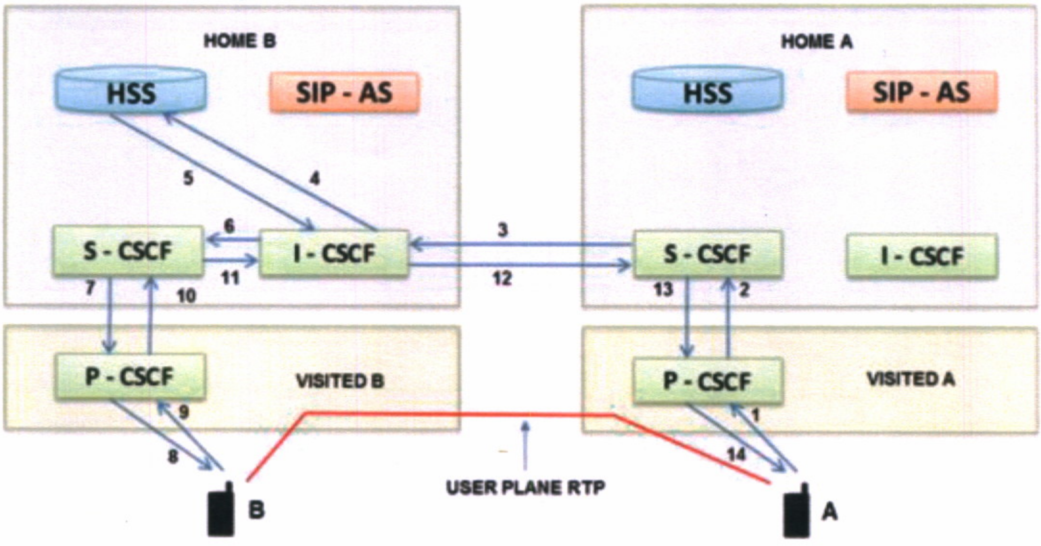

Fig. 5. Basic IMS Call.

- Steps 1 and 2: Depending on the location, the user connects to the appropriate IMS network (P-CSCF), which forwards the SIP "INVITE" request to the S-CSCF that already had on the table for this client at the time of registration.
- Step 3: The S-CSCF checks that the destination in the SIP "INVITE" request is in another network, and redirects it, previously doing a DNS lookup in order to find the IP address of the I-CSCF in the destination network.
- Steps 4 and 5: The I-CSCF has to check (with the HSS) which is the S-CSCF associated with the destination user and redirects the SIP "INVITE" request.
- Steps 6 and 7: The S-CSCF has the customer profile (already registered), and forwards the SIP "INVITE" request to the IP address of the appropriate P-CSCF in order to redirect the signalling packet.
- Step 8: The end user receives the SIP "INVITE" request and replies with a SIP "200-OK" response, together with the audio/video codecs and RTP/RTCP ports for the RTP path.
- Steps 9, 10, 11, 12, 13 and 14: The SIP "200-OK" response is redirected to the calling terminal to set the RTP flow. RTP path is established.

In the case of a communication where users (either the originator or the receiver) have additional value added services (conference, music on-hold, call forwarding, messaging box, etc.), additional SIP signaling messages have to be routed from the S-CSCF to the appropriate AS, according with the profile of each customer, and act accordingly (eg, start some service or redirect the session).

7. The Current View of Technology Specialists Argentina

After several meetings with specialists in the IMS technology, we can make the following comments. Regarding the barriers to entry for the development of this technology, two factors are sighted quite clearly.

First of all, some difficulty is perceived regarding the way of fund deployment (the Business Case does not match yet). Moreover, the complexity of the technology makes the implementation should be done gradually, since most existing services will be affected in the long-term.

The detail of the perceptions of specialists regarding barriers to implementation can be seen in the following figure 6.

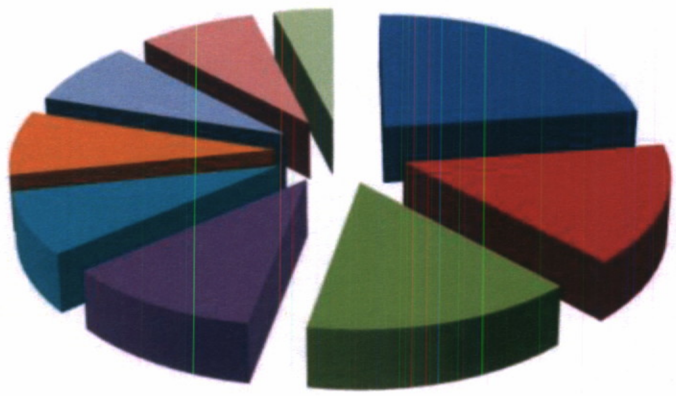

Fig. 6. Barriers to the implementation of IMS.

We also asked about what services are considered the drivers for the development of IMS. The perception here is that the main driver of this technology will be the RCS (Rich Communication Suite), followed by Mobile IP and the Application Stores developed by the operators. In the following table we can see the results of this consultation.

HD Voice	5%
Mobile IP	24%
RCS	33%
Operator App Store	19%
IP Centrex	5%
Others	9%
Do not know / do not answer	5%

Table 1. Drivers for the development of IMS.

According to the different brands, we have worked on the 5 most important ones that are developing IMS solutions, and we observed that one of them (Ericsson) has the leadership with an overall of 36%, followed by all the other ones with a positive perception between 14 and 18%. The detail can be found in the following Table.

Alcatel – Lucent (ALU)	14%
Nokia Siemens Network (NSN)	17%
Huawei	18%
ZTE	14%
Ericsson	36%
Do not know / do not answer	1%

Table 2. Global positive perception about IMS Providers.

8. Prospective

IMS technology is under testing and deployment. If we look prospectively to 3 years, we can see that suppliers must work hard on developments to achieve a good performance with different access networks, and high levels of reliability and security. They must devote significant resources in debugging their systems, as some pilot tests and some first commercial implementations will be made in these years, and is at this stage where the problems that have to be debugged will appear.

While most of the rules are already defined, they use to be recommendations that providers interpret and implement in different ways.

For mobile access, it is essential to tender new frequency bands in the regions that need to incorporate 4G networks (LTE).

The detalis of the interconnection between the carriers that implement IMS is another item that has to be considered. This will begin with the completion of the first pilot tests and will occur by the end of this period, or perhaps for the fourth year, since the interconnections between carriers require that everyone had stable networks. With the IMS interconnection between carriers, the multimedia services will achieve full interoperability, leaving the encapsulation within each provider.

At the end of these three years, the convergence between fixed and mobile technologies is also expected, especially driven by the IMS architecture with LTE as the access technology, working together in an IP Core.

9. Suggestions for Best Practices

Our Vision on best practices for the implementation of IMS services is to select and use technology (supplier) that has better perception by specialists. This has the advantage, among others, that much of the architecture modules are actually integrated software modules that are being executed in servers. The fact that they are integrated prevents the existence of interoperability faults between the different modules, which could occur in the solutions in which they reside on different hardware and even, in some cases, with equipment and software from different vendors.

The comparison between a fully integrated solution by the same manufacturer versus a multi-vendor integrated solution is a historical discussion on the development of telecommunications. Experience shows us that the very new technologies require debugging processes and generally are resolved more quickly when all the variables needed to work with are concentrated within a single company.

Regarding the carriers that provide IMS services, a gradual integration of the different services is recommended, so that it is easier to verify the reliability and stability. The migration of existing services already running on other platforms is also recommended, allowing a quick turn back in the case of appereance of unexpected faults.

Regarding the Business Case, the downward trend in overall communications services is observed, so that the income that the IMS technology will support will initially emerge from the strategic assessment that carriers give to their implementation (assessment that has to be high). The dump of the existing services that are being performed today with other platforms, will provide income to the business plan at the initial stage.

Once deployed the IMS network and migrated the existing services, marketing areas will develop products that will be oriented to both Small and Medium Enterprises and Large Companies. Due to the layered structure, the IMS technology enables development of applications by companies that do not need to be related with the networks that will contract the IMS services to the carriers.

This scenario of creation of new services will generate new revenue from enterprises, service providers and end customers, which will make an affordable business plan.

10. Conclusions

The IMS will generate independence between the provision and development of services and the way to access them, both in terms of the network that is used as the terminal type.

The Service Providers observe, in this technology, the ability to increase revenues through the implementation of new services and lower costs associated with the services provided at present, thus improving their revenue streams.

The IMS technology is in its development phase, especially with regards to operational deployments, although there are some of them that already exist. In Argentina, the leading telecommunications companies are working on the issue. In one of them, they already have the equipment for the implementation of the services, making some pilot tests, together with some of them in the lab, next to the migration of a first service.

The above shows that the IMS technology is already established in Argentina, being the future of communications, and will be a cornerstone in the way of convergence of ICTs.

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