The Role of IMS Functional Architecture in Next Generation Network

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Abstract: The migration to Next Generation Networks is a sea change, a fundamental transformation that is expanded all over the world. It provides converged services over IP. In fact, NGN operates at session layer of OSI model and is aiming to make IP environment deterministic. This is done through establishing end-to-end sessions among communicating parties. From functional architecture perspective NGN is divided into two mainly stratums which are defined separately, but the main focus in this paper is the IP Multimedia subsystem which is in the service stratum of NGN. IMS is the evolution of the core network vision, where both signaling and bearer are carried over the IP layer, contemplated in the early 2000s by the 3rd Generation Project (3GPP) and the 3GPP2 standards bodies. IMS was later extended by TISPAN for fixed services. It enables the attached end devices to support personalized experience involving simultaneous voice, data, and multimedia sessions. In this paper all the important IMS components are described, according to the TISPAN. In addition to the Core IMS functional architecture, some of its near neighbors which are related to IMS are discussed. In conclusion, it is inferred a key feature of IMS is that the IP network is extended all the way to the user equipment, making the core network access agnostic and enabling all-IP communications throughout.

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1. Introduction

The Next Generation Network (NGN) is intended to support a set of assured (and best-effort) end-to-end services over a network composed of heterogeneous sub-networks, and based on the Internet Protocol (IP). One of the main characteristics of the NGN architecture is the uncoupling of services and underlying transport functions (i.e. network technologies) (ETSI TS 102 855 V1.1.1 2011), allowing services and transport to be offered separately and to evolve independently (ITU-T Rec. Y.2011 2004; ETSI TS 102 855 V1.1.1 2011). Therefore, in the NGN architectures there is a clear separation between the functions for services and for networks, and open interfaces are provided between them. Provisioning of existing and new services can then be independent of the transport network and the access technology. In addition the "external" network services are allowed to use their native protocols as was specified in the NGN architecture and interwork with other networks over standardized interfaces and interworking modules. This facilitates the inclusion of more networks, from cable to 4G, within the NGN infrastructure.

Other characteristics of the NGN defined by TISPAN concern the management of overall services and networks (Network Management) through an Operational Support System (OSS). ITU-T (SG-13), ETSI (TISPAN), IETF and 3GPP have defined NGN networks and services and the work on this subject is continuing. There are differences between the details of NGN definitions (including architectures) of the standards organizations; for example, ES 282 007 on the Core IMS Functionality of TISPAN is a subset of the 3GPP UMTS Architecture defined in TS 123 002 and is restricted to session control functionalities. In turn the TISPAN session control was adopted by 3GPP.

The core IMS excludes Application Servers (AS) that host Access Functions (AF) and transport/media related functions such as the Multimedia Resource Function Processors (MRFP) and the IMS Media Gateway function (IMS-MGW) that is service or network specific. Nevertheless, there is a specific set of features and generally common understanding and convergence across the core functionality, and much of the work on standards is being pursued under the responsibility of the ETSI TISPAN WG (ETSI TS 102 855 V1.1.1 2011).

In the present paper the TISPAN definitions and terminology for NGN and IMS are more focused.

1. 1. TISPAN NGN Architecture

The NGN functional architecture described in the present document complies with the ITU-T Y.2012 general reference model for next generation networks.It is structured according to a service layer and an IP-based transport layer (ETSI ES 282 001 V3.4.1 2009).

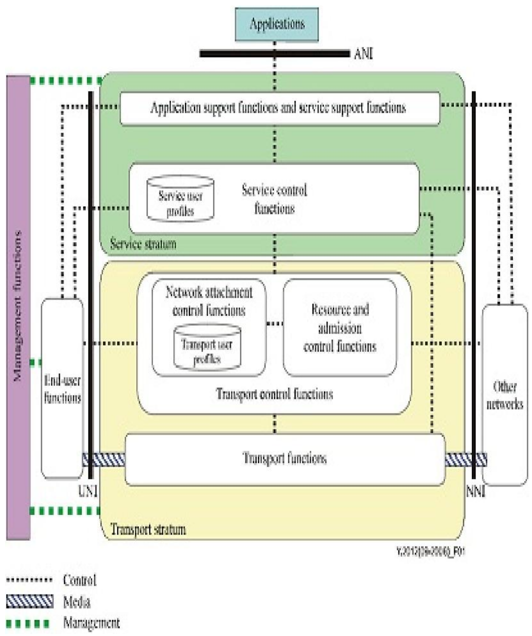

Figure 1. Y.2012 – NGN architecture overview
Separation of services from transport in NGN

The separation of services from transport, allowing them to be offered separately and to evolve independently, is the key cornerstone of NGN (Figure 1) (ITU-T Rec. Y.2011 2004).

In figure 1 the user network interface (UNI), network interface (NNI), and application network interface (ANI) should be understood as general NGN reference points that can be mapped to specific physical interfaces depending on the particular physical implementations (ITU-T Rec. Y.2012 2006).

1.1.1. The Transport Layer

The transport layer comprises a transport control sub-layer on top of transport processing functions in the access and core networks (*Figure 2*) (ETSI ES 282 001 V3.4.1 2009; ETSI TS 102 855 V1.1.1 2011).

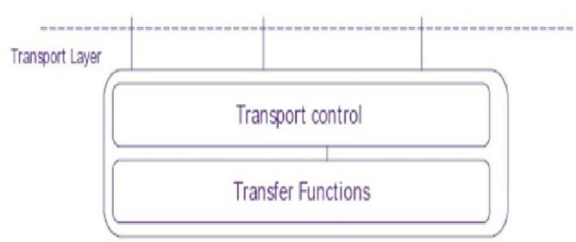

Figure 2: The two sublayers of the Transport Layer

1.1.2. Transport Control

The transport control sublayer consists of two subsystems: the network attachment subsystem (NASS) and the resource and admission control subsystem (RACS) (ETSI ES 282 001 V3.4.1 2009).

1. NASS- The Network Attachment Subsystem (NASS) provides registration at access level and initialization of User Equipment (UE) for accessing to the TISPAN NGN services. The NASS provides network level identification and authentication, manages the IP address space of the Access Network and authenticates access sessions. The NASS also announces the contact point of the TISPAN NGN Service/Applications Subsystems to the UE.

Network attachment through NASS is based on implicit or explicit user identity and authentication credentials stored in the NASS (ETSI ES 282 004 V3.4.1 2010).

This subsystem provides the following essential functions:

- Dynamic provisioning of IP addresses and other terminal-configuration parameters
- Authentication at the IP layer prior to or during the address-allocation procedure
- Authorization of network access based on user profiles
- Access network configuration based on user profiles
- Location management at the IP layer

Note: The user profiles mentioned above are related to the access subscription only (ETSI ES 282 001 V3.4.1 2009; ETSI ES 282 004 V3.4.1 2010).

2. RACS— Basically offers to Applications Functions (AF) the following functionality on a one per RACS resource reservation session request basis:

- Admission Control: RACS implements Admission Control to the access and aggregation segment of the network. One can imagine various types of admission control going from a strict admission control where any overbooking is to be prevented, to admission control that allows for a certain degree of over subscription or even a trivial admission control (where the authorization step is considered sufficient to grant access to the service).
- Resource reservation: RACS implements a resource reservation mechanism that permits applications to request bearer resources in the access and aggregation networks.
- Policy Control: RACS uses service based local policies to determine how to support requests from.

Applications for transport resources. Based on available information about resource availability and on other policy rules (e.g. priority of the application) RACS determines if a request can be supported and (if successful) RACS authorizes appropriate transport resources and defines L2/L3 traffic polices that are enforced by the bearer service network elements.

- NAT transversal: RACS controls the transversal of far end (remote) NAT.

- NAT/Gate control: RACS controls near-end NAT at the borders of the NGN core network and at the border between a core network and an access network.

RACS offers services to Application Functions (AF) that may reside in different administrative domains (Final draft ETSI ES 282 003 V1.1.1 2006).

1.1.3. Transport processing functions

Transport processing functions in the access and core networks include basic elementary functions supporting packet forwarding and routing, and more specific group of functions defined as functional entities (Figure 3) (ETSI ES 282 001 V3.4.1 2009).

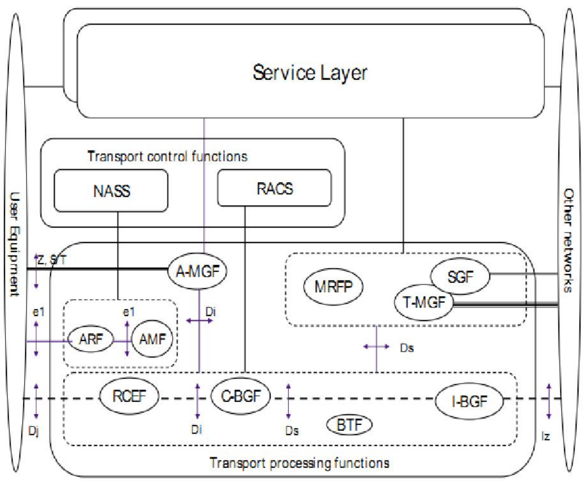

Figure 3. A detailed view of the transfer functions sub-layer

1.2. The Service Layer

The service layer consists of several key subsystems (Figure 4). The NGN needs to support a wide variety of application services. In the Service Stratum therefore, while IMS is at the heart of all emerging NGN standards, it is just one of a number of Service Control Subsystems.In addition to the Service Control Subsystems, the Service Stratum includes a number of common functional entities that can be accessed by more than one subsystem (ETSI TS 102 855 1.1.1 2011). In this document we focus on Core IMS in detail and some of other Subsystem and common components in NGN architecture which are connected to it.

1. Core IMS subsystem— The IP Multimedia Subsystem (IMS) core component of the NGN architecture (Core IMS) supports the provision of SIP-based multimedia services to NGN terminals. It also supports the provision of PSTN/ISDN simulation services.
2. PSTN/ISDN emulation subsystem
3. Other multimedia subsystems (e.g. streaming subsystem, content broadcasting subsystem etc.) and applications.
4. Common components (i.e. used by several subsystems) such as those required for accessing applications, charging functions, user profile management, security management, routing data bases (e.g. ENUM) (ETSI ES 282 007 V1.1.1 2006, ETSI ES 282 001 V3.4.1 2009, Subscription Locator Function, Application Server Function, Interworking Function (ETSI TS 102 855 V1.1.1 2011).

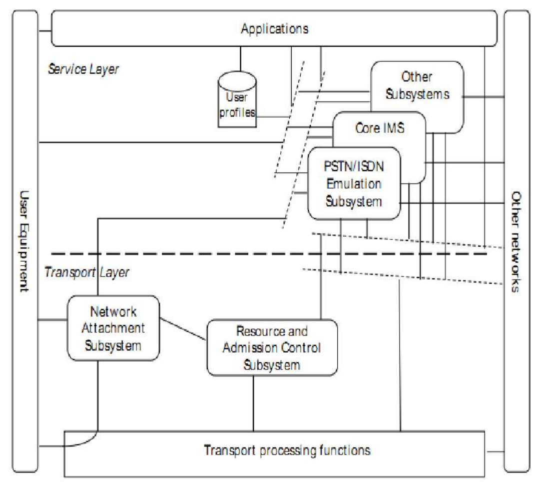

Figure 4. A detailed view of the service layer

2. Introduction to IMS

IMS was initially called IP Multimedia Subsystem — that is, the subsystem that manages multimedia services. This "subsystem" consists of the CN (Core Network) elements necessary for the provision of IP multimedia services (i.e., audio, video, text, chat, image, and a combination of them) delivered over PSNs (Packet-Switched Networks). It was soon realized that, in fact, this is the very center of the network, providing service control for multiple access networks. To reflect that, it is now referred to in standards documentation as the IM (IP Multimedia) CN Subsystem. However, the short reference of IMS remains the popular name for it.

The real value of IMS emerged when it became clear that this subsystem can provide an integrated control layer for many types of access, combining not only Internet services with communications, but also Mobile and Fixed networks. IMS provides service ubiquity for roaming or nomadic users. This brings opportunities for Visited Networks as well as Home Networks. IMS defines the underlying standards, including standards for security, quality-of-service, and interoperator accounting. (Copeland Rebecca 2008).

2.1. The Evolution of IMS (The TISPAN Approach)

TISPAN is an ETSI group that evolved from the fixed network standards (TIPHON) to define IP standards for NGN (Next Generation Networking) and migration from Fixed Line networks.

TISPAN work drove forward the idea that Mobile and Fixed connections can be converged not only with common transport, but also with common core components (Copeland Rebecca, 2008).

TISPAN works closely with the 3GPP to bring about the fixed mobile convergence to the NGNs, it proposes to use 3GPP IMS for SIP-based applications but adds new components and functional blocks to handle non-SIP applications and other requirements of fixed broadband networks that are not addresses by the 3GPP IMS.

The TISPAN Release 1 architecture which was published in December 2005 is based on the 3GPP IMS Release 6 architecture but is intended to address the wireline provider's requirements.

The architecture uses a 3GPP IMS core where subsystem share common components, while allowing the addition of new components over time in order to cover new demands and service classes. It ensures that the network resources, applications and user equipment that are inherited from IMS are common, thereby ensuring user, terminal and service mobility. Release 1 concentrated on the architecture and functional components and not on the NGN applications. Release 2 is expected to address this gap by defining real-life NGN services such as media streaming and others (Khalid Al-Begain and et al 2009).

The TISPAN early definition of Core IMS, with elements that have been defined already by the 3GPP and endorsed by TISPAN, include some functions that have been added by TISPAN, such as AGCF (Access Gateway Control Function), A-BGF (Access Border Gateway Function), RACF (Resource and Admission Control Function), and others. The TISPAN architecture extends the architecture for tethered connections. It specifies the two principal connection types: (1) analog Fixed phones interfaces and (2) IP terminals with advanced multimedia capabilities. These types of terminals require two types of feature management:

1. Emulation. For analog phone to be connected to the Core IP network, TISPAN developed emulation methods that retain almost all the PSTN features, and subscribers may not even notice that they connect to a new IP network.

2. Simulation. For other terminals with multimedia capabilities, TISPAN defined the simulation method, where the same services can be delivered in a different way, with a different format, and with different user interfaces.

TISPAN developed additional subsystems to complement Core IMS. In particular, the NASS (Network Attachment Sub-System) and the RACS (Resource and Admission Control Subsystem) are instrumental in the multi-access capability of IMS.

TISPAN also has developed further the procedures at the network border, both on the access side and on the network interconnection side. The control of the border point is the role of the IBCF (Interconnection Border Control Function) that instructs the BGF (Border Gateway Function) to enforce security and routing across the border. The I-BGF (Interconnecting BGF) connects to other IP networks. The C-BGF (Core BGF) connects the IP-CAN to the Core network. The A-BGF (Access BGF) is a border gateway at the access side that applies border control between the CPE (Customer Premises Equipment) server and access networks.

Network Address Translation (NAT) has always been an important issue with NGN where the connection is between elements that maintain different addressing plans. Interworking between private and public NAT zones and between IPv4 and IPv6 are facilitated at the border servers as well as security filtering of packet headers and payload. The IWF (Interworking Function) has been added to smooth out incompatibilities between implementations of SIP or translation of IMS signaling to non-IMS communication (e.g., H.323) (Copeland Rebecca, 2008).

2.2. The IMS Architecture

The IMS standards are maturing now with a wide range of functions and network elements. Some areas of functionality lend themselves to merging for all types of access and for “tethered” (Fixed) and “untethered” (Mobile) communications (Copeland, 2008).

The NGN IMS, also known as "Core IMS" is a subset of the 3GPP IMS which is restricted to the session control functionalities. Application Servers (AS) and transport/media related functions such as the Multimedia Resource Function Processor function (MRFP) and the IP Multimedia Gateway Functions (IM-MGW) are to be outside the "core IMS".

Although essentially identical to the 3GPP IMS entities, NGN IMS functional entities might exhibit minor variations in behaviour, due to differences in access networks and user equipment. However, the NGN IMS architecture defined in the present document remains compatible with 3GPP-defined IP-connectivity access networks (IP-CAN) and as such can provide services to user equipment connected to both fixed broadband access and 3GPP IP-CANs (ETSI ES 282 007 V1.1.1 2006).

Figure 5 provides an overview of the functional entities that compose the NGN IMS, the reference points between them and with components outside the IMS.

2.2.1. Internal functional entities

2.2.1.1 Call Session Control Function (CSCF)

The CSCF is the session controller, the nerve center of Core IMS (Copeland Rebecca 2008). The Call Session Control Function (CSCF) establishes, monitors, supports and releases multimedia sessions and manages the user's service interactions (ETSI ES 282 007 V1.1.1 2006; ETSI TS 102 855 V1.1.1 2011).

The CSCF can act as Proxy CSCF (P-CSCF), Serving CSCF (S-CSCF) or Interrogating CSCF (I-CSCF) (ETSI ES 282 007 V1.1.1 2006; ETSI TS 123 002 V9.2.0 2010; ETSI TS 102 855 V1.1.1 2011; ETSI TS 102 261 V1.1.1 2003).

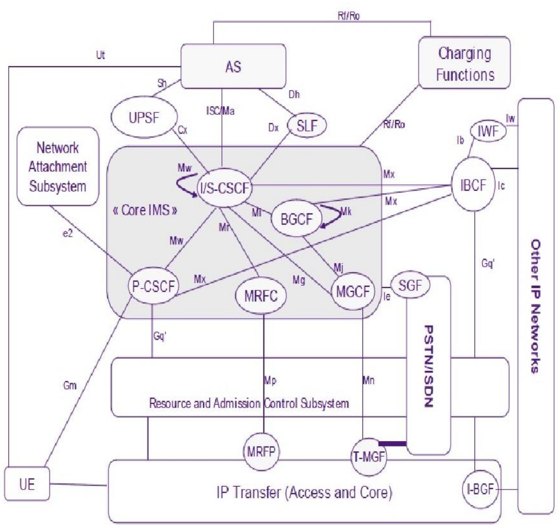

Figure 5. Overview of the functional entities compose the NGN IMS

The Serving CSCF (S-CSCF) acts as a switching center with access to full user details. It connects sessions, maintains session state and links to appropriate applications, and subsequently produces charging records. It is responsible for the triggering of the subscribed applications in the right sequence and for management of mid-call events as well as orderly call termination (Copeland Rebecca 2008).

The I-CSCF is mainly the contact point within an operator's network for all IMS connections destined to a subscriber of that network operator, or a roaming subscriber currently located within that network operator's service area (ETSI ES 282 007 V1.1.1 2006-06; ETSI TS 123 002 V9.2.0 2010; ETSI TS 102 261 V1.1.1 2003).

It interrogates the HSS for locations of S-CSCF for users and routes to Home Networks. In case of transit the I-CSCF may have extra functionality for routing transit traffic (Copeland Rebecca 2008).

The P-CSCF is the first contact point for the UE within the IM subsystem (IMS) (ETSI ES 282 007 V1.1.1 2006; TS 123 002 V9.2.0 2010; ETSI TS 102 855 V1.1.1 2011; ETSI TS 102 261 V1.1.1 2003). In convergence model, the Proxy CSCF (P-CSCF) acts on behalf of the SIP user as a proxy for sending messages to network servers, assisting in admission control, authentication, and resourcing. It fields all signaling messages, such as registration, re-registrations, and session INVITE messages to the appropriate network servers. It also plays a key role in the Visited Network, routing messages between the user access side and the network border (Rebecca Copeland 2008).

There are two points about CSCF In this paper which should be marked:

- The P-CSCF defined in the present document encompasses ALG functionality required to interact with Network Address and Port translation functions located in the transfer plane, via the RACS.
- The P-CSCF defined in the present document interfaces with the Network Attachment Subsystem (NASS) in order to retrieve information related to the IP-connectivity access session (e.g. physical location of the user equipment).

2.2.1.2. Breakout Gateway Control Function (BGCF)

The BGCF (Breakout Gateway Control Function) is the signaling server that determines where to exit the current network. The BGCF can be set up as an exit contact point on various internal network servers, and connects to several IMS nodes (Copeland Rebecca 2008).

When the destination requires a PSTN breakout or connection to another IP network. The BGCF determines the next hop for routing the SIP message (ETSI TS 123 002 V9.2.0 2010; ETSI TS 102 855 V1.1.1 2011; Copeland Rebecca 2008), for example, to a media gateway controller (Copeland Rebecca 2008). The BGCF selects the network in which PSTN breakout is to occur and – within the network where the breakout is to occur - selects the MGCF (ETSI ES 282 007 V1.1.1 2006; TS 123 002 V9.2.0 2010; ETSI TS 102 855 V1.1.1 2011; ETSI TS 102 261 V1.1.1 2003).

2.2.1.3. Media Gateway Control Function (MGCF)

The MGCF (Media Gateway Control Function) is the server that enables IMS to communicate to and from PSTN or ISDN by determining the media path and media management requirements (ETSI TS 102 855 V1.1.1 2011; Copeland Rebecca 2008).

The MGCF is responsible for controlling the media channels in an IMS-MGW (IMS Media Gateway) (ETSI TS 123 002 V9.2.0 2010; Copeland Rebecca 2008; ETSI TS 102 261 V1.1.1 2003) and the call state that relates to that media connection. It determines the next hop for the media path, depending on the routing number for the legacy networks (ETSI TS 123 002 V9.2.0 2010**;** ETSI TS 102 855 V1.1.1 2011; Copeland Rebecca 2008).

It also performs protocol conversion between ISUP TCAP and the IMS call control protocols (ETSI TS 102 855 V1.1.1 2011; ETSI TS 102 261 V1.1.1 2003; Copeland Rebecca 2008;ETSI TS 123 002 V9.2.0 2010; TS 288 007 V9.2.0 2010). The Media Gateway Controller Function (MGCF) provides the ability to control a trunking media gateway function (T-MGF) through a standardized interface (ETSI TS 102 855 V1.1.1 2011; ETSI ES 282 007 V1.1.1 2006).

Such control includes allocation and deallocation of resources of the media gateway, as well as modification of the usage of these resources (ETSI ES 282 007 V1.1.1 2006).

The MGCF communicates with the CSCF (ETSI ES 282 007 V1.1.1 2006; ETSI TS 123 002 V9.2.0 2010; ETSI TS 102 261 V1.1.1 2003) the BGCF and circuit-switched networks. (ETSI ES 282 007 V1.1.1 2006; ETSI TS 123 002 V9.2.0 2010; ETSI ES 282 007 V1.1.1 2006), The MGCF performs protocol conversion between ISUP and SIP **(**ETSI TS 102 261 V1.1.1 2003; ETSI ES 282 007 V1.1.1 2006; ETSI TS 123 002 V9.2.0 2010). It also supports interworking between SIP and non-call related SS7 signaling (i.e. TCAP-based signaling for supplementary services such as CCBS). In case of incoming calls from legacy networks, the MGCF determines the next hop in IP routing depending on received signaling information (ETSI ES 282 007 V1.1.1 2006; ETSI TS 123 002 V9.2.0 2010).

In case of transit the MGCF may use necessary functionality for routing transit traffic.

2.2.1.4. Multimedia Resource Function Controller (MRFC)

The MRFC (Media Resource Function Controller) is the signaling controller element that interacts between the media processor and the requestors of media services (Copeland Rebecca 2008).

The Multimedia Resource Function Controller (MRFC), in conjunction with an MRFP located in the transport layer (ETSI ES 282 007 V1.1.1 2006; ETSI TS 102 855 V1.1.1 2011), provides a set of resources within the core network for supporting services. The MRFC interprets information coming from an AS via an S-CSCF and control MRFP accordingly (ETSI TS 123 002 V9.2.0 2010; ETSI ES 282 007 V1.1.1 2006; Rebecca Copeland 2008).

The MRFC, in conjunction with the MRFP, provides e.g. multi-way conference bridges, announcement playback, media transcoding etc (ETSI TS 102 855 V1.1.1 2011; ETSI ES 282 007 V1.1.1 2006).

3 The PSTN/ISDN Emulation subsystem (PES)

The PSTN/ISDN Emulation Subsystem supports the emulation of PSTN/ISDN services for legacy terminals connected to the NGN, through residential gateways or access gateways(ETSI ES 282 001 V3.4.11, 2009).

PSTN/ISDN emulation functions as a subsystem within an NGN at the same level as the IMS. Consequently it uses the same general interfaces as the IMS to the Transport, Network Attachment and Resource and Admission Control subsystems and Support Functions. However the semantics are not always the same in every case (Final draft ETSI ES 282 002 V1.1.1, 2006).

4. Application Server Types

Three types of Application Server Functions (ASF) can be accessed by the IMS through the ISC or Ma reference point (figure 6).

- SIP Application Servers (SIP AS);
- The IM-SSF Application Server;
- The OSA SCS Application Server.

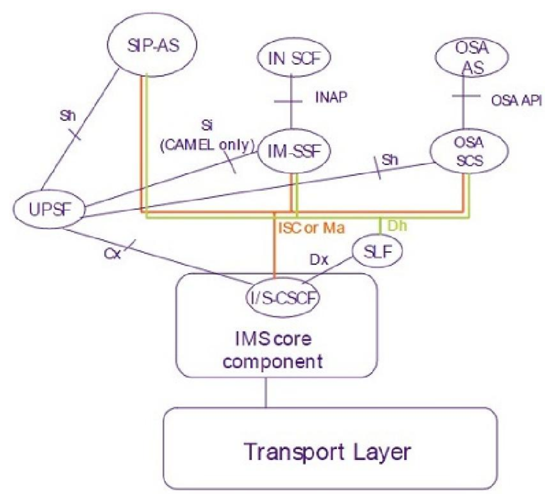

Figure 6. Application Server as a Value Added Services architecture

A SIP Application Server may contain 'Service Capability Interaction Manager' (SCIM) functionality and other application servers. The SCIM functionality is an application which performs the role of interaction management. The internal structure of the application server is outside the standards (ETSI TS 123 002 V9.2.0 2010; ETSI ES 282 007 V1.1.1 2006).

The purpose of the IM SSF is to enable access to IN service logic programs hosted in legacy SCPs. The IM-SSF functionality encompasses the emulation of the IN Call Model (BCSM) on top of SIP signalling, IN triggering and feature management mechanisms, emulation of the IN Service Switching Finite State Machine and interworking with INAP.

The purpose of the OSA Service Capability Server is to provide access to OSA applications. The Service-CSCF to AS interface is used to forward SIP requests, based on filter criteria associated with the originating or destinating user (ETSI ES 282 007 V1.1.1 2006).

The Interrogating-CSCF to AS interface is used to forward SIP requests destined to a Public Service Identity hosted by the AS directly to that AS (ETSI ES 282 007 V1.1.1 2006;ETSI TS 123 002 V9.2.0 2010).

5. User Profile Server Function (UPSF)

The User Profile Server Function (UPSF) is responsible for holding the following user related information:

- Service-level user identification, numbering and addressing information.
- Service-level user security information.
- Service-level user location information.
- Service-level user profile information.

The UPSF may store user profile information related to one or more service control subsystems and applications.

The UPSF does not contain profile information related to IP connectivity subscriptions. Such information is held in the Network Attachment SubSystem (NASS). However, where it makes sense in the context of a particular business model, the UPSF may be co-located with the data base function of the NASS (ETSI ES 282 001 V3.4.11, 2009).

The UPS (User Profile Server) is the equivalent of HSS in the TISPAN specifications. The UPS

(or UPSF) contains user profiles and service subscription data similar to the HSS, but excludes the HLR location management (Copeland Rebecca, 2008).

6. Discussions

From a user's perspective, today's networks have come a long way in fulfilling their purpose of enabling people and their machines to communicate at a distance. However, a key critical success factor (among many) is focused telecommunications industry attention on NGN service concepts and how these concepts can be realized in an NGN environment, from the edges to the core of the network.

The target of NGN is to ensure that all elements required for interoperability and network capabilities support applications globally across the NGN while maintaining the concept of separation between transport and services.

With IMS, mobile or nomadic customers can still have access to a wealth of personalized services independent of their mode of access. The increased popularity of this concept has brought about the need for a wireline access network architecture that can take advantage of core IMS concepts.

An IMS–based architecture is one in which all services offered to a particular customer can access the same subscriber database. This enables a service provider to offer customers a consistent set of personalized services, independent of the access media they Use.

Fixed IP networks include several access methods, namely xDSL, cable, or Metro Ethernet. Fixed wireless LANs are also in this category, with WLAN WiFi and WiMAX. The future integrated network must support all these access methods.

Core elements definitions are reasonably stable now and able to process session requests from different access networks. Convergence work is continuing in various subsystems interfacing to Core IMS, in particular the charging functions and resource control.

So to outline the answer of this question "Why IMS in NGN?" There are two points to describe:

• IMS generally fulfills the NGN requirements for conversational services
–Managed, carrier operated telecom network
–IMS Release 6 becomes applicable to a range of access network types (3G RAN, WLAN)
–IMS is access technology independence
• Telecom industry benefit
–Will enable simple and effective inter-working between Cellular and Wire line
–Growing IMS market, encouraging greater usage
–Wider choice of IMS suppliers
–Market stimulation, decreasing costs (thanks to shared development/deployment costs).

References

1. ITU-T Recommendation Y. (2011). General principles and general reference model for Next Generation Networks.
2. ITU-T Recommendation Y. (2012). Functional requirements and architecture of the NGN release 1
3. ETSI ES 282 001. (2009). Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); NGN Functional Architecture.
4. ETSI TS 102 855 V1.1.1. (2011). Satellite Earth Stations and Systems (SES); Broadband Satellite Multimedia (BSM); Interworking and Integration of BSM in Next Generation Networks (NGNs).
5. Copeland R. (2008). Converging NGN Wireline and Mobile 3G Networks with IMS,Publisher CRC Press.
6. ETSI ES 282 007 V1.1.1, 2006-06, Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); IP Multimedia Subsystem (IMS);Functional architecture.
7. Khalid Al-Begain, Chitra Balakrishna, Luis Angel Galindo, John Wiley & Sons. (2009). IMS: A Development and Deployment Perspective, Wiley; 1 edition.
8. ETSI TS 123 002. (2010). Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Network architecture (3GPP TS 23.002 version 9.2.0 Release 9).
9. Final draft ETSI ES 282 003 V1.1.1. (2006). Telecommunications and Internet Converged Services and Protocols for Advanced Networking (TISPAN); Resource and Admission Control Sub-system (RACS); Functional Architecture.
10. ETSI ES 282 004 V3.4.1. (2010). Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); NGN Functional Architecture; Network Attachment Sub-System (NASS).
11. ETSI TS 102 261 V1.1.1. (2003). Open Network Services and Architecture (ONSA); Abstract architecture and reference points definition; Mapping of functional architectures and requirements for NGN.
12. Final draft ETSI ES 282 002 V1.1.1. (2006). Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); PSTN/ISDN Emulation Sub-system (PES); Functional architecture..

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