IMS in the Next Generation Network

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Abstract: NGN based on IMS (IP Multimedia Subsystem) will bring many benefits to network operators. Operators that deploy it can potentially offer a much wider range of applications and services, to subscribers irrespective of their location, at reduced cost and complexity. IMS will allow operators to increase their revenues through the additional services that can be offered, while their capital expenditure and operation expenses will decrease with their migration from legacy TDM networks to converged network architectures. With the increasing penetration of Wireless Local Area Networks (WLANs) and emerging Wireless Metropolitan Area Networks (WiMax) as access network technologies, the IMS scope is now extended within the ongoing Release 7 standardization for any IP access network, including fixed access networks, i.e. DSL (Digital Subscriber Line). Particular the later aspect has also driven NGN standardization bodies, such as ETSI (European Telecommunications Standards Institute) and ITU-T (International Telecommunications Union – Telecommunications Sector) to consider the IMS as an important service control platform for their NGN standards. In this paper, the IMS-based NGN architecture principles and functions as provided in the ETSI TC TISPAN specifications and ITU-T Recommendations are presented in section 2 and 3. The comparison of the both architectures is given in section 4. Finally, the next steps in the standardization path towards the full NGN are presented in section 5.

Key-Words: Next Generation Network, IMS (IP Multimedia Subsystem), convergence, standardization, ETSI TC TISPAN, ITU-T.

1 Introduction

Over the last few years the telecoms industry has seen unparalleled growth in fixed-mobile converged services and networks. Fixed-mobile convergence presents the integration of wireline and wireless technologies and services to create a single telecommunications network environment. It promises to overcome some of the physical barriers that now prevent telecom service providers from reaching all of their potential customers with all types of services.

Out of the wireless standards consortium called 3rd Generation Partnership Project (3GPP) comes a slow-growing and complicated collection of carrier network functions and processes that collectively are referred to as IMS, which stands for the IP (or Internet) Multimedia Subsystem. The IMS standards promise an operator-friendly environment for real-time, packet-based calls and services that not only will preserve traditional carrier controls over user signalling and usage-based billing, but also will generate new revenue via deep packet inspection of protocols, URI and content. IMS was conceived for the evolution of cellular telephony networks, but the benefits of user signalling and billing controls have attracted the endorsement and involvement of wireline network operators and standards makers, including the ETSI, especially its Technical Committee TISPAN (TC TISPAN), the U.S.-based Alliance for Telecommunications Industry Solutions (ATIS) and the ITU-T. Other standardization organizations and fora such as the Internet Engineering Task Force (IETF), 3GPP, 3GPP2, CableLabs, MultiService Forum (MSF), and Open Mobile Alliance (OMA) are actively involved in defining NGN standards.

2 ETSI TISPAN NGN Architecture

2.1 Sub-system approach

TC TISPAN developed a functional architecture [1] consisting of a number of sub-systems and structured in a service layer and an IP-based transport layer. This sub-system oriented architecture enables new subsystems to be added over time to cover new demands and service classes. It also provides the ability to import sub-systems defined by other standardization bodies. Each subsystem is specified as a set of functional entities and related interfaces. Figure 1 shows the overall NGN functional architecture.

2.1.1 NGN Transport Layer

The transport layer provides the IP connectivity for NGN users. The transport layer is composed of a transport control sub-layer on top of transfer functions. The transfer control sub-layer is further divided into the Network Attachment Subsystem (NASS) and the Resource and Admission Control Subsystem (RACS).

The NASS provides registration at the access level and initializes terminal accessing to NGN services [2]. There may be more than one NASS to support multiple access networks.

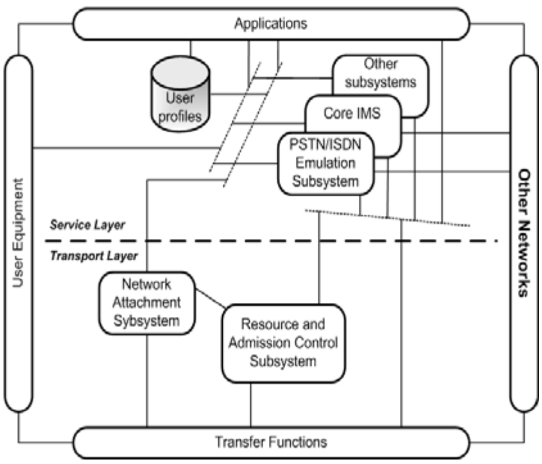

Figure 1: TISPAN_NGN – Concept of Sub-systems

The RACS provides applications with a mechanism for requesting and reserving resources from the access network [3].

2.1.2 NGN Service Layer

The NGN service layer comprises:

- Core IP Multimedia Subsystem (IMS)
- PSTN/ISDN emulation subsystem (PES)
- Other multimedia subsystems (e.g., streaming subsystem, content broadcasting subsystem)
- Common components used by several subsystems (e.g., subsystems required for accessing applications, charging functions, user profile management, security management).

The core network of NGN Release 1 is based upon the IMS, as defined in 3GPP Release 6 and 3GPP2 revision A for IP-based multimedia applications. The IMS is IP end-to-end and allows applications and services to be supported seamlessly across all networks. IMS is a framework architecture – a definition of capabilities specified in 3GPP documents that defines components, services and interfaces for NGN. It uses Voice over IP (VoIP) implementation based on a 3GPP standardized implementation of Session Initiation Protocol (SIP), and it runs over the standard Internet protocol (IP). 3GPP has enhanced the SIP and IP-based protocols (primarily Diameter) to allow for mobility. The TISPAN TC has adopted the IMS and is closely working with 3GPP on any modifications or improvements that may be needed for the NGN [4].

There are three distinct operational layers (or planes) within the IMS architecture: the Application Layer, Control Layer and the Transport Layer (Figure 2).

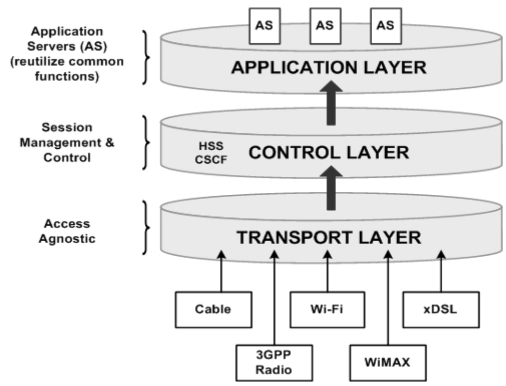

Figure 2: Three IMS Layers

The Application Layer contains a number of application server (AS) types. These are all SIP entities as expected within the IMS architecture. These servers host and execute services and can operate in a number of SIP functional modes i.e., SIP UA (User Agent), a terminating function; SIP B2BUA (Back-to-Back User Agent) which acts like two back to-back SIP user agents or as a SIP proxy server.

The Control Layer deals with session signalling and comprises a number of distinct functions to process the signalling traffic flow, such as the Call Session

Control Functions (CSCF), Home Subscriber Server (HSS), Media Gateway Control Function (MGCF) and Media Resource Function Controller (MRFC). Using protocols such as SIP, Diameter and H.248 MEGACO, the various elements are able to establish subscriber requested services.

The Transport Layer transports the media streams directly between subscribers; and between subscribers and IMS media generating functions, such as the media resource function processor acting as a media announcement server.

The core IMS functions are included in the Call Session Control Function (CSCF) which is a SIP server processing the IMS signalling traffic in order to control multimedia sessions. There are three types of CSCF:

- Proxy CSCF (P-CSCF): The initial point of contact for signalling traffic in to the IMS. A user is allocated a P-CSCF as a part of the registration process, and provides a two-way IPsec association with the user; all signalling traffic traverses the P-CSCF for the duration of the session.
- Serving CSCF (S-CSCF): Provides the service coordination logic to invoke and orchestrate the application servers needed to deliver the requested service. The S-CSCF interacts with the HSS in order to determine user service eligibility by downloading the user profile; the S-CSCF is allocated for the duration of the registration.
- Interrogating CSCF (I-CSCF): A SIP proxy that provides a gateway to other domains, such as other service provider networks. The I-CSCF may encrypt sensitive domain information a function referred to as Topology Hiding Internetwork Gateway (THIG) before forwarding the traffic.

Until Release 6, specifications for the P-CSCF included the Policy Decision Function (PDF), which stores policies and consults them to make decisions about IP bearer resource allocation requests. The PDF has been separated from the P-CSCF to make it more accessible to WLANs and other access network types. P-CSCFs also generate CDR or billing records that can be consolidated at a Charging Gateway Function (CGF).

The 3GPP IMS has been extended in the TISPAN NGN [4] to support additional access network types, such as xDSL and WLAN.

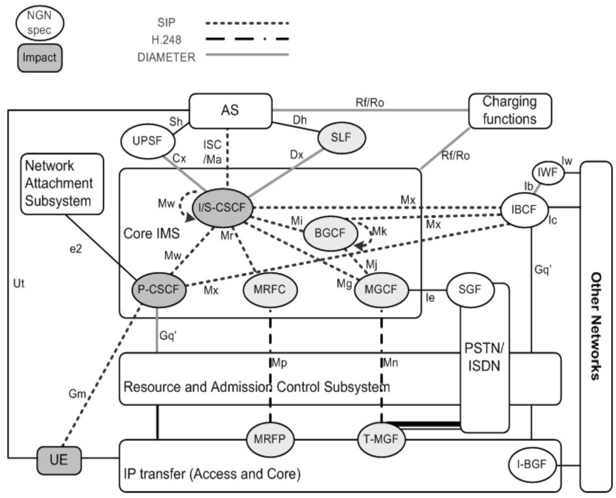

Figure 3: Core IMS in the TISPAN_NGN

The TISPAN extensions of the 3GPP IMS (Figure 3) take into account the differences between the wireless and wired environments, especially as far as concerns the amount of control needed for the end user device that leads to huge differences in perspectives on control and management. As a more specific example, there is no equivalent in wire-line networks to the so-called smart cards used to identify mobile customers and trigger billing activity when they make calls from another wireless operator’s service territory. For the both environments, there are also different regulatory constraints, QoS and location definitions, methods and mechanisms, support requirements for legacy devices as well as many differences in security and network management details.

PSTN/ISDN Emulation Subsystem (PES) [5] is a subsystem that supports emulation of PSTN/ISDN services, enabling legacy PSTN terminals to access the NGN through Residential, Access and Trunking Gateways.

Streaming Subsystem provides support for RTSP-based streaming services to NGN terminals.
The architecture of the streaming subsystem is outside the scope of TISPAN NGN Release 1.

Content Broadcasting Subsystem enables broadcasting of multimedia content (e.g. movies, TV channels etc.) to NGN subscribers. The architecture of the content broadcasting subsystem is outside the scope of TISPAN NGN Release 1.

Common components are those that can be accessed by more than one subsystem. Two types of common components can be identified:

- Components known in 3GPP IMS
- New components defined by TISPAN.

The first group of components has been defined by 3GPP IMS. It includes the following functions:

- Subscription Location Function (SLF) is only needed when multiple HSSs are used. Within TISPAN, it can be accessed by service control subsystems and Application Server Functions to retrieve the identity of the UPSF containing the service-level user profile of a particular subscriber.
- Application Server Function (ASF) offers value added services and resides either in the user's home network or in a third party location. The third party could be a network or simply a stand-alone AS.
- Interconnection Border Control Function (IBCF) which provides the interconnection with other multimedia sub-systems.
- User Profile Server Function (UPSF) which is, in fact, a subset of the HSS defined by 3GPP. It stores all relevant information regarding the user, including identification, addressing, numbering, access controls and location information. Unlike HSS, UPSF does not provide HLR/AuC functionality.
- Charging and Data Collection Functions: As the names suggest, these provide data collection and billing mediation for online and offline charging.

The second group represents either new components that have been defined by TISPAN, or those 3GPP ones that have been modified by TISPAN in the context of NGN:

- Application Server Function (ASF) may provide standalone services or value added services on top of a basic session. For resource control purposes in NGN, the first category of Application Server Functions (ASF Type 1) may interact with the RACS, while the second category (ASF Type 2) relies on the control subsystem that provide the basic session over which the valued added service is built. Examples of Application Server Functions are SIP Application Servers and OSA Application Servers. When sitting on top of the IMS, the second type of ASF is identical to the Application Server (AS) function defined by 3GPP, although a network node implementing this functional entity in an NGN network and a network node implementing it in a 3GPP network may differ in terms of supported services.
- Inter-working Function (IWF) is a new component that performs the interworking between protocols used within TISPAN NGN service control subsystems and other IP-based protocols (e.g. between the SIP profile used in the IMS and other SIP profiles or IP-based protocols such as the H.323 protocol).
- Charging and Data Collection Functions include data collection functions and mediation functions to the billing systems (for supporting both on-line and off-line charging) or other management applications that may use the same data. It should be noted that charging in TISPAN Release 1 is limited to offline charging only. There are several functional entities in the Core IMS that may act as charging trigger points (AS; BGCF; (I-/P-/S-) CSCF; MGCF; MRFC. Moreover, TISPAN has defined the Interconnection Border Control Function (IBCF) to which the Core IMS is connected as another kind of charging trigger point. However, no CDR has been defined in Release 1 for the IBCF.

3. ITU-T NGN Architecture

The functional requirements and architecture of the Next Generation Network (NGN) for Release 1 are specified in ITU-T Y.2012 [6]. This document defines Functional Entities (FEs) of the NGN and is a precursor to further identifying and designating reference points, and defining information flows across such reference points.

The functional architecture provided in this Recommendation allows a clear distinction between the definition/specification aspects of services provided by the NGN and the actual specification of the network technologies used to support those services. In line with Y.2011 [7] principles, an implementation-independent approach is adopted.

Figure 3 shows an overview of the NGN functional architecture that allows the support of the Release 1 services. The NGN functions are divided into service stratum functions and transport stratum functions according to the ITU-T Recommendation Y.2011 [7].

To provide these services, several functions in both the service stratum and the transport stratum are needed, as illustrated in Figure 4.

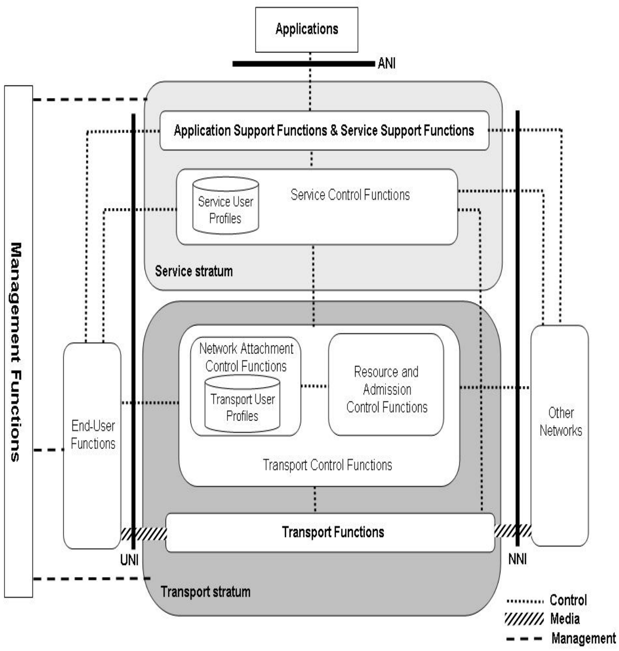

Figure 4: ITU-T NGN architecture overview

The transport stratum is that part of the NGN which provides the user functions that transfer data and the functions that control and manage transport resources to carry such data between terminating entities. The later group of functions is further divided into:

- Resource and Admission Control Functions (RACF) and
- Network Attachment Control Functions (NACF) and a user profiles function.

Further details about the functionalities of the RACF and NACF can be found in ITU-T Recommendation Y.2012 [7].
The service stratum is that part of the NGN which provides the user functions that transfer service-related data and the functions that control and manage service resources and network services to enable user services and applications.

4 Comparison of the ETSI and ITU-T NGN Functional Architectures

As depicted in the figures 1 and 4, both the ETSI as well as the ITU-T NGN functional architectures are in line with regards to the separation between transport and services defined in ITU-T Recommendation Y.2011.

4.1 Transport Layer/Stratum

The TISPAN Transport Layer is equivalent to the ITU-T Transport Stratum. The TISPAN Resource and Admission Control Subsystem (RACS) corresponds to the ITU-T Resource and Admission Control Functions (RACF).

The TISPAN Network Attachment Subsystem (NASS) corresponds to the ITU-T Network Attachment Control Functions (NACF), except for the Profile Database Function (PDBF) functional entity which in the ITU-T case is equivalent to the User Profile Function sitting outside the NACF.

4.2 Service Layer/Stratum

ITU-T and ETSI TISPAN have used different approaches to the specification of the service layer/stratum architecture.

The TISPAN architecture uses a subsystem oriented approach. Each subsystem relies on its own architecture model and is specified independently from the others. This enables the addition of new subsystems over the time to cover new demands and service classes. It also provides the ability to import and adapt subsystems defined by other standardization bodies such as the IMS.

ITU-T specifies a generic functional model of the service layer/stratum that is independent of the type of services and protocols used. This model may then be instantiated into more specific models, known as service components.

In the both cases, only two components/subsystems have been specified within the scope of Release 1 standards: a component/subsystem for supporting multimedia services (IP Multimedia Subsystem) and a component/subsystem for supporting PSTN/ISDN emulation.

It should be noted that ITU-T service components are roughly equivalent to ETSI TISPAN subsystems in the service layer.

3 TISPAN NGN Releases

ETSI TISPAN NGN Release 1, published in December, 2005, provides the first set of implement able NGN specifications that are being used by industry to build the NGN. It incorporates the following capabilities: real-time conversational services, messaging (IM and Multimedia Messaging Service (MMS)), and content delivery (e.g., video on demand). Release 1 supports multimedia services with nomadicity/user-controlled roaming based on use of a Network Attachment Subsystem (NASS). NASS supports user nomadicity and roaming with an xDSL access focus. Besides NASS, the main features include the definition of the Core IP Multimedia Subsystem and its relationship to other TISPAN NGN components, Resource and Admission Control Subsystem (RACS), PSTN/ISDN Emulation Subsystem (PES) and PSTN/ISDN Simulation Services (PSS).

In Release 2, focus is done on synchronization of TISPAN NGN specifications with 3GPP, especially the alignment of the timescales and dependencies of TISPAN Release 1 with the work in 3GPP Release 7 on Fixed Broadband IMS (FBI) and the alignment of the timescales of TISPAN Release 2 with the ongoing work in 3GPP Release 8 and Fixed Mobile Convergence (FMC). The objective is to reach a single core solution based on IMS Core signalling technology and multiple access technologies in cooperation with 3GPP (e.g., ADSL
WLAN via xDSL, 3GPP IP-CAN (GPRS, WLAN via GPRS, etc.)). Release 2 architecture issues include new functionalities such as:

- Evolution of RACS including resource control in the core network, end-to-end QoS, optimizing access resource usage according to user subscription profile and service use.
- Evolution of NASS including additional access technologies, e.g., fixed access via xDSL (e.g. ADSL), WLAN via xDSL (e.g. IEEE 802.11), WiMAX etc.
- Support for the IPTV.
- Online Charging.
- Overload control by means of Generic Overload Control Activation Protocol (GOCAP) as a single, generic, control of processing overload in NGN.

4 Conclusion

The convergence between public switched telephone networks and IP based data networks forms a major part of the TISPAN work, along with the planning for the re-use in the fixed domain of the, originally mobile only, "IP Multimedia Subsystem" (IMS) developed in 3GPP.

IMS is the coming standards-based NGN architecture of choice for today's wireless, wireline and broadband operators. The primary driver behind IMS is a move away from circuit-switched services toward IP packet-based services. However, IMS will support both systems. And because the framework is access agnostic, IMS allows operators to continue to use different underlying network architectures.

IMS is expected to respond to and solve many of the industry's biggest technological challenges, including the lack of interoperability among operators who offer the same services and the inability of operators to take advantage of converged networks. However, IMS implementation should be viewed as a strategy of migration rather than replacement of an entire network. Operators can decide and choose which elements to implement, so the migration to IMS can be gradual. In other words, IMS can be viewed as a roadmap for operators that can guide them through an evolution to fully converged networks, services and technologies – a process that is already underway.

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