NGN Networks: A New Enabling Technology or Just a Network Integration Solution?

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ABSTRACT

The Next Generation Networks (NGN) technology has been launched by the International Telecommunication Union (ITU) and the European Telecommunications Standards Institute (ETSI) as a method for establishing convergence of IP communications. This paper analyses the dynamics of Next Generation Networks (NGN) technology in implementing network convergence. The focus is given on the IP Multimedia Sub-system (IMS), the first NGN implementation. Description pivots around analysis of IMS internals, aiming at providing evidence that IMS is not just an integration solution but has potential to play the role of an overlay network architecture for future applications, as enabling technology.

Categories and Subject Descriptors

C.2.1 Network Architecture and Design

General Terms

Algorithms, Management, Performance.

Keywords

IMS, UMTS, Next Generation Networks, Mobility Management

1. INTRODUCTION

A method for establishing convergence of IP communications was launched some years ago by the International Telecommunication Union (ITU) and the European Telecommunications Standards Institute (ETSI) by introducing the Next Generation Networks (NGN) technology. ITU has published many recommendations on NGN many of which are still under preparation by the Next Generation Network Global Standards Initiative (NGN-GSI), while ETSI has focused its work on service provisioning issues within the context of the Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN) workgroup.

In ITU-T Recommendation Y.2001 [1], NGN is defined as a QoS-enabled, packet-based communication architecture, compatible with all know IP transport network technologies and capable of providing network independent services.

The main aim of NGN is to offer service providers a method for delivering uniform services to end users and terminals in a network, exhibiting a number of common characteristics (Figure 1):

- convergence of services, i.e. data, multimedia, voice, video, under a common service delivery framework,
- integration of fixed, wireless and mobile network technologies into a common communication architecture,
- integration of a common set of handover and roaming procedures for all mobile and wireless networks.
- QoS enabled calls between same-technology and different-technology networks, i.e. mobile to fixed, fixed to wireless, etc,
- Independency from user terminals. All terminals are supported as long as they are IP compatible,
- user-driven service creation and execution,

According to ITU, NGNs are built up as an overlay architecture on top of IP-based transport networks (Figure 1). Service discovery, request and activation follows the concept of ‘sessions’, whereby user operations, such as authentication, network registration and tarrifing, are administered by the SIP protocol, while data transport is negotiable and varies in respect with the capabilities of the underlying network.

Despite the pioneering work of ITU, early experiments on NGN networks deployment have been hosted in 3G UMTS networks, leading 3GPP, the standardization body of UMTS, to adopt NGN from its UMTS Release 5 [2], under the name IP

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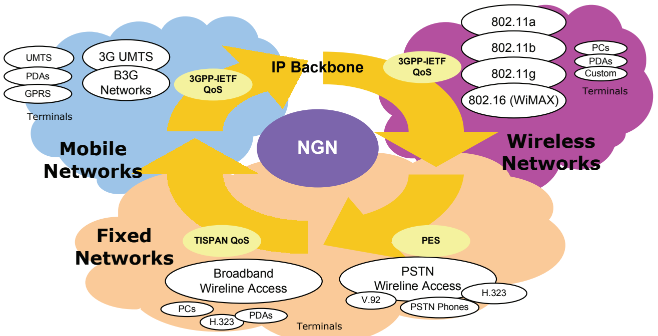

Figure 1: NGN Technology; A converged communications ecosystem.

Multimedia Sub-system (IMS). In its UMTS Release 6 [3]. 3GPP has also covered interworking issues between wireless (WiFi, WiMax) and mobile networks. Concerning fixed networks, IMS has been adopted by ESTI-TISPAN, and the work is focused on the development of generic mechanisms for mapping the QoS classes defined by 3GPP on fixed access networks, so as to allow interworking with mobile and wireless networks.

The reminder of the paper is organized as follows: Section 2 presents the principles of IMS, while Section 3 describes the integration of contemporary IP networks. Following (Section 4), the integration of network architectures for advanced mobility management is discussed in detail. In section 5 the VITAL experimental IMS network is presented, while in Section 6 the Future Evolution is discussed. Finally, Section 7 concludes the paper.

2. THE PRINCIPLES OF IMS

Thanks to its QoS capabilities and compatibility with most access network technologies, IMS can easily accommodate multimedia services. Due to their versatile nature, multimedia services can be realized in IMS networks with dedicated server, the so called Application Servers (AS), which can handle multimedia sessions' initialization and maintenance between the end-points and perform conventional user operations, such as authentication in the network and billing.

By definition, in IMS, AS are independent of the underlying network and handle only the signaling part of user communication, using the SIP protocol, while the protocols of the transport part are always negotiable, judging from the capabilities of the user terminal and the underlying network, and may vary from RTP/RTCP to RSVP and IGMP.

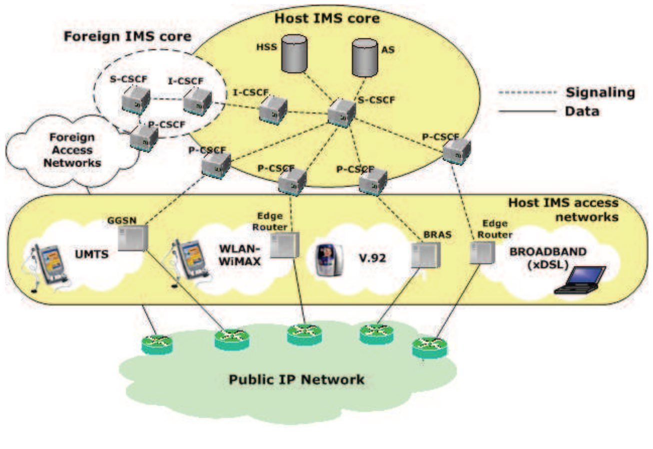

Figure 3: General overview of the IMS Architecture.

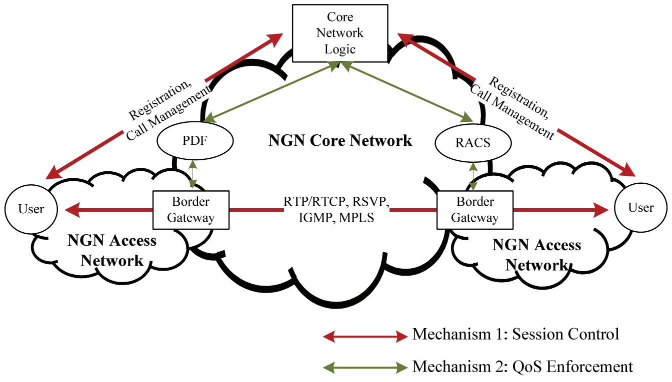

Figure 2: Deployment of the session control and QoS enforcement mechanisms in NGN networks.

IMS classifies services in real-time conversational services, such as video-telephony/conferencing, voice communication, and non-conversational services, such as video-on demand, instant messaging, chating.

Both service types are implemented with the two mechanisms depicted in (Figure 2), both of which are realised using the SIP protocol. The first mechanism called 'session control' allows the user to be identified, authenticated and charged by the network on the basis of his IMS Personal Identity (IMPI). Also the same mechanism allows the user to identify and activate services of point-to-point (conversational) or point-to-multi-point type (e.g. conferencing).

The second mechanism called 'QoS Enforcement' is destined to setting up paths suitable for hosting the requested service by translating the QoS values into appropriate traffic parameters, such delay variation, packet loss ratio, etc. In UMTS/wireless access networks, set up of QoS is implemented with Policy Decision Functions (PDF), while in fixed networks QoS is set up by the Resource and Admission Control Subsystem (RACS).

While PDF and RACS are relevant for establishing QoS on the border gateways of the access networks, QoS establishment across the whole network requires additional resources reservation functions in the core network, such as DiffServ or other, dynamic methods involving packet labeling like MPLS.

2.1 The IMS Architecture

Figure 3 gives an overview of the IMS architecture. IMS forms an overlay network that integrates users belonging to different access networks with a number of higher level signaling operations using SIP. Following this 'decoupled' from the underlying networks communication concept IMS becomes independent from the transport protocols and the type of services that can be hosted in each network. Furthermore, by adopting the AS concept described earlier, in the realization of user services, IMS succeeds in staying independent of the type of services offered to users as well as the type of communication (point-to-point or point-to-multipoint).

By definition, an IMS network is uniquely identified by the S-CSCF component. A single IMS network is considered as being a "host" network, which collaborates with "foreign" IMS networks for servicing roaming users.

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2.1.1 Main Components

An IMS host network is built with a set of signaling processing components and data flow management mechanisms. Among them, the Call Service Control Function (CSCF) plays a prominent role in handling users' requests. CSCFs are responsible for the tasks of a) call translation and routing, b) QoS management, c) configuration of data trans-coding functions, and d) service integration with the user profiles and access privileges. CSCF is assumed these roles through the following manifestations:

- The Proxy CSCFs (P-CSCF) are located at the borders of an IMS network with the underlying network and implement interception and routing of user calls towards the appropriate P-CSCF of the destination network.
- The Servicing CSCF (S-CSCF) accepts signaling messages from the P-CSCFs and relates them to user identities, privileges and charging records, all located at the host IMS network database.
- The Interrogating CSCS (I-CSCF) implements interoperability of the 'host' IMS network with 'foreign' ones, whereby profiles, service accessibility privileges and charging records are exchanged in cases where an IMS user roams his session towards access networks not connected to the 'host' IMS network.

In addition to the CSCF logic, IMS employs a Home Subscriber Server (HSS) where it hosts user related data, such as profiles, access privileges and charging records.

To deal with the vast variety of signaling procedures utilized by underlying networks, IMS has adopted the SIP as the protocol of choice for integrating underlying network operators into IMS operations. SIP is a general-purpose, easy-to-implement application layer protocol originally designed for call management in IP networks, hosting operations like 'session' establishment, modification and release. In contrast to the H.323 protocol of ITU, SIP has an open, easily deployable structure, and extensible message format, allowing easy integration of new message fields and types.

3. INTEGRATION OF CONTEMPORARY IP NETWORKS

In [4], 3GPP defines the logical interfaces for interconnecting the aforementioned IMS components, giving them the topology depicted in Figure 4. In this figure, the logical interfaces implemented using the SIP protocol are marked with dotted lines and with continuous lines the interfaces implemented with transport protocols.

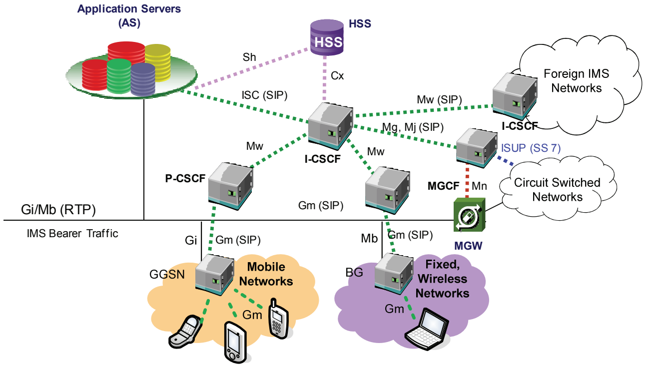

Figure 4: Layout of logical interfaces for access networks integration with the IP Multimedia Core Network.

Concerning the first category, the Gm interface [4] implements the signaling communication between the IMS user and the core network, offering the following functions for:

- P-CSCF discovery and utilization.
- Service utilization requests and response from the network.
- Mobility management.

The Mw interface comes in two versions; one for network-to-network communication (NNI) and one for user-to-network communication (UNI). The first version is used for handling signaling messages exchange with 'foreign' IMS networks, while the second one is used for the communication of the S-CSCF and the P-CSCFs of the same IMS network. In addition, the S-CSCF communicates with HSS and the ASs via the Cx interface and the IP multimedia Subsystem Service Control Interface (ISC), respectively.

The ISC interface is used for exchanging messages between the AS and the S-CSCF pertaining to the user identity, registration state, terminal capabilities and service access privileges, while an AS communicates with the HSS through the Sh, an intra-operator interface over which the network performs policing of registered users.

Via the Gm interface, a user can get connected to the IMS network and be provided with a number of generic procedures, including:

- User registration: The IMS network performs user identification, based on recognition of user's IMPI and performs user registration for a certain number of services in accord with user privileges and profile.
- Roaming: The user may freely roam into a foreign IMS network, while using an IMS service, without suffering service disruption or communication quality degradations.
- Handover: Likewise to roaming, users may continue using an IMS service, while moving and their terminal performs session handovers from one mobile/wireless location area into another.
- Service charging: Service utilization costs is flat and independent of the access network, allowing for first time decoupling of service provisioning from the underlying network infrastructure.

To implement QoS mapping on the data path, 3GPP and ETSI's TISPAN have specified a number of extra control interfaces having the physical layout shown in Figure 5.

The purpose of Gq, Go and Gq', Go' interfaces is to enforce the user requested QoS parameters in the access network and in the backbone network interconnecting the access networks involved in the call. This is mainly done through appropriate Connection Admission Control (CAC) mechanisms that perform:

- Translation of user requested QoS parameters into a generic set of channel descriptions, consisting of traffic parameters, like delay variation, loss ratio and data rate.
- Harmonized bandwidth allocation in backbone networks connecting the access networks, taking into account the

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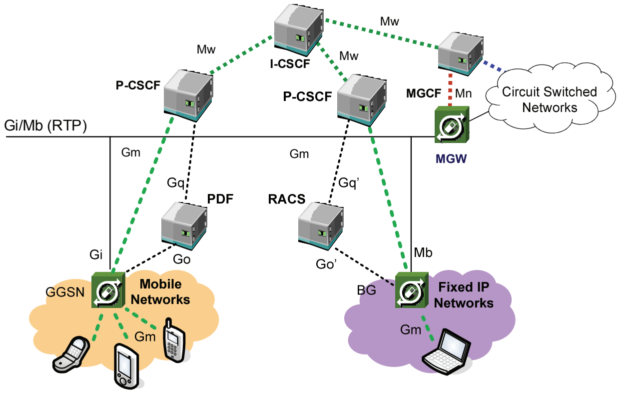

Figure 5: Signaling interfaces and data paths for IMS data traffic routing across heterogeneous access networks.

QoS capabilities of the access networks and the available QoS allocation mechanism on the core network.

- Arbitration of user demand concerning bandwidth allocation, taking into account the traffic conditions of the core and the access networks.

4. INTEGRATION OF NETWORK ARCHITECTURES FOR ADVANCED MOBILITY MANAGEMENT

UMA (Unlicensed Mobile Access) is a set of specifications that allow users, not belonging to the host mobile network to get connected and access network's services in a network and bearer-agnostic manner.

According to the UMA specifications, initial interaction of the Mobile Station (MS) with the cellular radio is achieved by using a non-cellular interface, e.g. Bluetooth and WiFi and setup an IPSec link with the UNC (UMA Network Controller). This way the cellular network can utilize existing protocols for AAA (Authentication Authorization and Accounting) as defined in 3GPP, without the need to define any new protocols. As it is depicted in Figure 6, in any UMTS version (2G or 3G), the Radio Access Network (RAN), authenticates the UMA user via a dedicated for this purpose AAA Proxy Server (Wm interface), which is connected to a dedicated HLR database that allows user recognition and credentials management.

For roaming users the proxy server contacts a remote AAA Proxy Server that maintains user profile and gets his credentials through the Wd interface. Recently 3GPP has included UMA in its specifications for UMTS under the term Generic Access Network (GAN) [5].

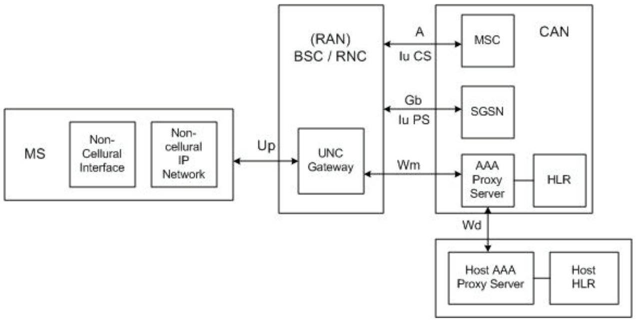

Figure 6: Integration of UMA with mobile networks

Since the IMS architecture is by definition independent from the procedures of the underlying networks, integration of UMA in IMS networks is done transparently, as long as the user has an IMPI to connect to the overlay IMS network.

In order to be able to perform user operations, the MS should have installed the SIP protocol and a set of SIP-based applications to trigger user authentication and registration in the IMS network and service activation over the Gm interface depicted in Figure 4.

5. THE VITAL EXPERIMENTAL IMS NETWORK

In order to test the integrity of mechanisms introduced by the IMS technology and particularly interoperability between 3GPP and TISPAN networks, the VITAL project [6] has setup the experimental network shown in Figure 7, which forms the first large scale operational IMS network in Europe.

In its current configuration the platform can offer services to mobile, wireless and fixed terminal users through the following communication interfaces:

- Mobile 3G UMTS access.
- Wireless 802.11x and 802.16x access.
- Broadband fixed network access.
- V.92 fixed network access.

Also, the platform supports connectivity with H.323 networks (Figure 6, top, first access network on the left), third party IMS core networks and circuit switched networks such as PSTN and ISDN (Figure 6, top, first and second access network on the right).

The dotted lines represent SIP signaling flows and the dashed lines represent the corresponding data paths. QoS control on the backbone network is realised as a combination of DiffServ and MPLS traffic routing mechanisms, while for better adjustment of data traffic to delay variations, the user terminals and the corresponding application servers employ RTP/RTCP for a number of medium sensitive user applications. The physical interconnection of the platform with the backbone IP network is realised by means of using VPN routers on the edges of the access networks.

Due to access network specificities, three different methods have been employed in the implementation of the signaling path:

- Through I-CSCF: This interconnection scheme has been implemented over the Mw interface connecting the SIP proxy of the access network with the I-CSCF of the target IMS core. With this configuration the access network retains its SIP users and their addressing schemes. Thus calls originating from this access network towards users belonging to other access networks of the VITAL platform are recognized as external calls, unless the I-CSCF supports HTTP digest functionality [7]. In the latter case, the users registered in the SIP server of the access network become local users of the interconnected IMS platform.
- Through P-CSCF using RACS: With this interconnection scheme the users of the connected access network become users of the interconnected IMS network and their QoS requirements can be enforced on the IP

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backbone through the RACS entity.

- Through P-CSCF using PDF: As in the previous case, the users registered in the SIP servers of the connected access network become registered users of the IMS platform and their communication requirements can be enforced on the IP backbone by means of using the PDF.

The VITAL network can host any type of IMS terminal as long as it employs the SIP protocol. Furthermore, apart from the Mobility Management Application Server (MMAS), the platform incorporates three additional Application Server types for voice, video streaming and data sharing multimedia services.

6. FUTURE EVOLUTION

Given the proved maturity of internal mechanisms in enabling interoperability of heterogeneous networks, in the future there will be two main issues that will monopolize developments in IMS technology. The first issue relates to mechanisms for enabling control of the data path over the entire backbone network, beyond the DiffServ model. DiffServ is not granular enough to support all QoS classes of IMS, while its applicability is always subject to the capabilities of the network. IMS attempts to solve this problem with the introduction of Application Specific Gateways, the so called SIP Application Level Gateways (SIP-ALG). The SIP-ALG can be seen as a dynamic method for binding the QoS parameters conveyed in the SIP protocol, judging from the capabilities of the underlying network. In its recent form, a SIP-ALG is supplied with a predefined IP address which is returned by the IMS network to the communication end-points in order to be used as the destination address for user packets. This way a SIP-ALG performs arbitration of the data traffic over the full communication path, including the backbone network, thereby safeguarding user-requested QoS values. Despite its merits, SIP-ALG is not compatible with IP based resource management protocols such as RSVP and IGMP and their operation becomes less efficient when servicing applications requesting more than two parties.

The second issue relates to the efficiency of the IMS mechanisms dedicated to implement mobility management [8]. Recent comparisons between mobility management procedures used in UMTS and IMS networks [9] have shown that IMS faces performance bottlenecks, which can be attributed to the duplication of UMTS mobility management procedures in the IMS network to ensure operations independency. However, in a real “ubiquitous” communication environment, consisting of dense hot spot networks from different operators, location updates and handovers will occur very often, causing frequent service disruptions and authentication rejections. In future, IMS signaling operations will be reviewed and new, optimized procedures will be proposed.

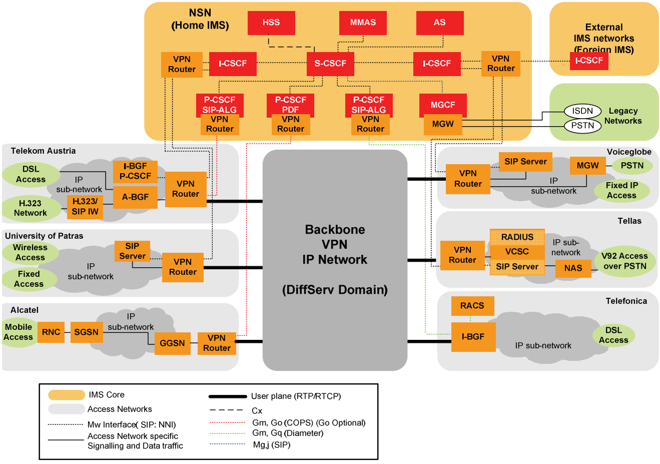

Figure 7: The experimental IMS platform of VITAL.

7. CONCLUSIONS

In this paper we give an overview of the NGN technology and the innovations it bears concerning network, service and terminal aspects. It has been shown that thanks to the converged communications concept and the adoption of the SIP protocol, users can talk with every possible mean, using video, audio and data, thus allowing new breads of services to emerge. Also, its generic architecture makes it independent from the data path protocols and allows accommodation of generic mechanisms for QoS handling. Considering all these merits we can easily yield an answer to the initial question, as to whether NGN is an enabling technology or an integration solution. NGN is an enabler technology that will continue shaping the future of communications. In the years to come NGN will become the main focal point of industry’s efforts towards 4G and its commercial roll-out will revitalize mainly the area of fixed networks, reshaping the way users think of communications.

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