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Personal Multimedia Services over a Common Home and Access Networking Environment

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Abstract

This article presents a new end-to-end architecture model that will enable the deployment of a plethora of different multimedia services from diverse suppliers competitively coexisting over a common access and home networking environment. The model is focused on personal multimedia communication services and terminals. The proposed model is a segmentation of the end-to-end multimedia chain into several business segments. The interfaces among segments and functional entities inside each segment are identified and defined in the work. In order to study the impact level of the results achieved, a comparison with the approximation to NGN provided by current standardization bodies in the field (3GPP and TISPAN) is also included in the article. This comparison highlights the advantages of using this model as a solution to offer PMC services.

Nowadays one of the most exciting trends in the telco and Internet landscapes is the confluence of the audio-visual, IP, and telecommunications industries toward a common next-generation network (NGN) infrastructure to deliver the same services using different types of access networks, also allowing a terminal to use several access networks.

An NGN is defined as a packet-based network able to provide telecommunication services and make use of multiple broadband quality-enabled transport technologies and in which service-related functions are independent of underlying transport-related technologies [1].

Several approaches to the NGN concept can be found, such as [2–4]. Reference [2] presents a proposal for an NGN architecture supporting TV over IP services. Reference [3] describes a distributed service architecture, which includes a middleware able to support presence services, thanks to the inherent features of NGNs. Finally, an NGN service architecture aimed at supporting composite services is proposed in [4]. However, these solutions exhibit two main limitations: first, they are mere conceptual proposals lacking concrete real implementations; and second, they are aimed at providing very specific services.

There are also a good number of solutions addressing quality of service (QoS) in these environments. For instance, [5] presents a QoS mechanism for improving the quality provided in NGNs, using Resource Reservation Protocol (RSVP)-like signaling for end-to-end resource reservation and following a philosophy similar to differentiated services (DiffServ) for sending data tagged with different QoS levels. However, again this mechanism is only presented on the theoretical plane, lacking an actual prototype implementation or objective data about its behavior or validation.

The Third Generation Partnership Project (3GPP) Release 6 has defined the IP multimedia subsystem (IMS) [6] as a first instantiation of the NGN architecture in the mobile field. The 3GPP IMS has become the standard for real-time multimedia communications services. Although the IMS specifications are oriented toward mobile networks, they also provide a solid basis for a fixed broadband network framework. In this way, European Telecommunications Standards Institute (ETSI) Telecommunications and Internet Converged Services and Protocols for Advanced Networking (TISPAN) [7] standardization work is focused on migrating IMS to the fixed access network scenario in the context of an overall NGN architecture.

Nevertheless, many open issues still need to be solved in order to achieve this migration toward supporting personal multimedia communication (PMC) services. Little research work can be found in recent literature aimed at solving some of these gaps; rather, most of it is focused only on specific topics such as quality [8] or wireless convergence [9], instead of addressing global solutions. The Multimedia Networking (MediaNet) project [10, 11] provides a new approach to NGN using IMS adaptation from TISPAN standardization, considering a larger scope than 3GPP or TISPAN in order to provide an adequate architecture for PMC services support.

To complete the picture, it is important to highlight that

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there are lots of variations in the functional breakdown between service provider, access network, home network, and terminal. There are also several alternative protocols, standards, and technologies providing the same capabilities. In such a context MediaNet project appears, and its results form the basis of this article.

MediaNet (IST FP6 Integrated Project no. FP6-507452) deals with multimedia content exchanges in digital networks. Targeting multimedia communications and content distribution services for residential markets, it addresses innovative supply chain architectures and cooperation schemes between content owners, service providers, network providers, and consumer electronics equipment manufacturers. The main objective of MediaNet is to produce a set of application solutions, key enabling technologies, and interfaces capable of reinforcing mutually dependent consumer electronics, telecommunication, and audio-visual business areas, covering three different but complementary domains: media networking, multimedia services, and content engineering.

In order to achieve these objectives, a reference model has been defined. This model identifies every party in the value chain as well as the interfaces interconnecting them. This work shows parties and interfaces for the particular case of the subset of services being considered in the MediaNet project: the PMC services which includes multimedia telephony, multimedia messaging (SMS, MMS, IM), plug-and-play terminal management and configuration (including software upgrade and non-PCM application downloads), user data management (contact list, calendar, etc.), and online directory services.

Due to its nature, PMC services may be accessed through a variety of terminals: hardware terminals (dedicated IP phones), software terminals (multipurpose machines like PCs or smartphones with dedicated software), and multiservice hardware terminals (devices dedicated to a limited number of PMC and non-PMC services, such as IPTV set-top boxes supporting videotelephony).

This article is organized as follows. The next section briefly introduces the reference model for PMC services. The overall functional network description is presented in the following section. We then propose the end-to-end QoS management in the PMC architecture. The main benefits of using the MediaNet model for the provision of PMC services with regard to IMS and TISPAN are then discussed. In the final section major discussion and conclusions related to this work are included.

Reference Model for PMC Services

This section describes the reference model designed inside MediaNet to represent PMC services.

Segmentation

The first work to be carried out is to identify the segments involved in the supply chain. This chain typically comprises four segments.

The first segment is known as *content creation*. This involves production and distribution of contents and software for PMC terminals.

The second segment, *service provider*, involves services supported by networks and infrastructures owned by an operator, including IP multimedia telephony, messaging, and online directory, all interacting with services of other public switched telephone networks (PSTN), cellular, and IP networks.

The third segment is the *access network*. In addition to the usual service provisioning, the MediaNet access network segment offers several advantages regarding PMC services, including network resource management, QoS, bandwidth on demand (BoD), multiservice subscriber profile management counting authentication, authorization, and accounting (AAA), multiservice billing service aggregation, access network security, and PMC terminal management.

Finally, the fourth segment is the *home network*, comprising all kinds of software and hardware, fixed and mobile PMC terminals connected via local networks to a home (residential) gateway.

Reference Architecture

The next step is to identify common interfaces and infrastructure elements according to the segmentation. Most standardization bodies (DSL Forum, ITU-T, ETSI TISPAN, DVB-IPI, DLNA, Packet Cable, etc.) have identified the need for an open broadband service architecture; the DSL Forum has already delivered relevant specifications. The MediaNet reference model and architecture are based on these specifications, in particular TR-58 [12] (the provisioning and public access part) and TR-94 [13] ("Multi-Service Delivery Framework for Home Networks"), as shown in Figs. 1 and 2 [14].

The interfaces considered in the MediaNet model are:

- The A10 interface between the application/network service provider (ASP/NSP) networks and the regional/access network (A10/ASP and A10/NSP, respectively).
- The U-R interface connecting the customer premises to the access provider network using specific broadband access technology (digital subscriber line [xDSL], cable, Ethernet, etc.).
- The TCN interface between the routing gateway (RGW) and the several distribution technologies connecting the different IP-capable customer devices within the customer premises.

PMC Scope Inside MediaNet Architecture

Starting with the general MediaNet reference architecture, PMC is focused on the service provisioning segment and the terminals in the end-user home environment, as depicted in Fig. 2.

The relationships between end users and the network are mediated by reference points T and A10 of the general reference architecture. The T reference point describes the behavior of the system from the end user's point of view, while the A10 reference point describes the behavior of the end user involved in a service from the ASP network point of view and the interface for the interaction with N-Services, a platform to speed up the creation and deployment of new services.

N-Services Platform

The segment between the A10 and U-R interfaces is called the N-services platform. The N-services platform is a software infrastructure for accelerating the introduction of innovative value-added services by ASPs. It is located in the network access provider domain, and exposes generic capabilities (the so-called N-services) through standardized interfaces and technology. These generic N-services can be (re)used by multiple ASPs.

Overall Functional Network Description

In the MediaNet model three network segments are considered. The first is the home network segment, which goes beyond simple broadband access. It considers a complex system of cooperating devices and terminals that share the same home network resources and access the external world through a residential gateway. This home network segment is composed of an RGW to provide the interface with the network

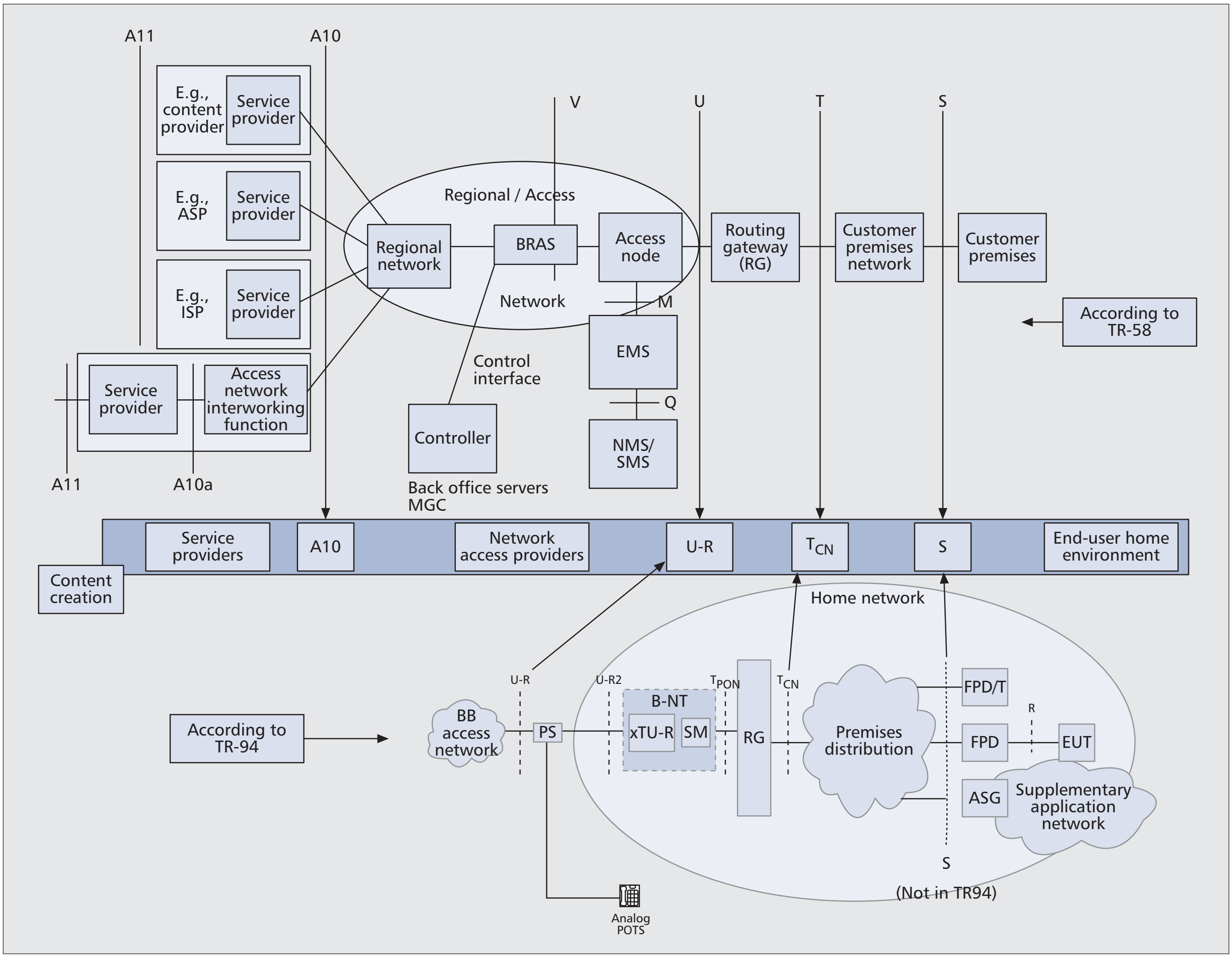

Figure 1. *MediaNet reference model.*

access provider (NAP), a home local area network (LAN), and PMC terminals.

The second segment is the NAP segment. It is not limited to the basic transport infrastructure connecting the residential gateway in the home network to the far end of the service session, but also provides a set of capabilities, called N-services, which allow the ASP environment to control some functionalities of the access network.

Finally, the third segment is the PMC ASP core network segment, which represents the glue that connects the two endpoints of the multimedia end-to-end services, allowing its provision with the specified quality parameters.

The overall network description [15] is depicted in Fig. 3 showing how the main functional entities distributed through the network segments of the MediaNet reference architecture and the interfaces between them.

This reference architecture provides effective information on how to build a real multimedia network that is able to support end-to-end PMC services with guaranteed resources, achieving desirable levels of quality, security, and terminal management.

Next, a brief description of the main entities involved in the MediaNet functional network is introduced.

PMC Terminal

The heart of the PMC terminal is the user PMC agent, a logical entity at the terminal side for the generation and reception of PMC service signaling and control of the media flows to/from an ASP PMC agent. This allows the provision of PMC services to the end-user PMC terminal. The user PMC agent takes direct advantage of two support modules: the universal plug and play (UPnP) QoS device and control point, and the UPnP Internet gateway device (IGD) control point.

The role of the QoS control point is to request of the QoS manager the home network resources needed for each traffic flow on behalf of the user PMC agent and to report the result to it. The role of the UPnP QoS device is to manage and configure the PMC terminal network interface on demand of the QoS manager and based on the policy result.

The UPnP IGD control point is in charge of managing the RGW on behalf of the user PMC agent for all the PMC services requesting some help for network address translation (NAT) traversal issues. Additional support operations are carried out by the rest of the modules of the PMC terminal. The media codecs and IP transport entities provide coding and decoding just like IP transport for different real-time media. The layer 2 and 3 QoS marker classifies traffic into several priority classes according to its needs. The Dynamic Host Configuration Protocol (DHCP) client provides the terminals with all LAN parameters needed (IP address, subnet mask, Domain Name System [DNS] server address, etc.). Finally, the role of the auto configuration client is to provide capabilities for plug and play, terminal configuration, and data and software upgrade.

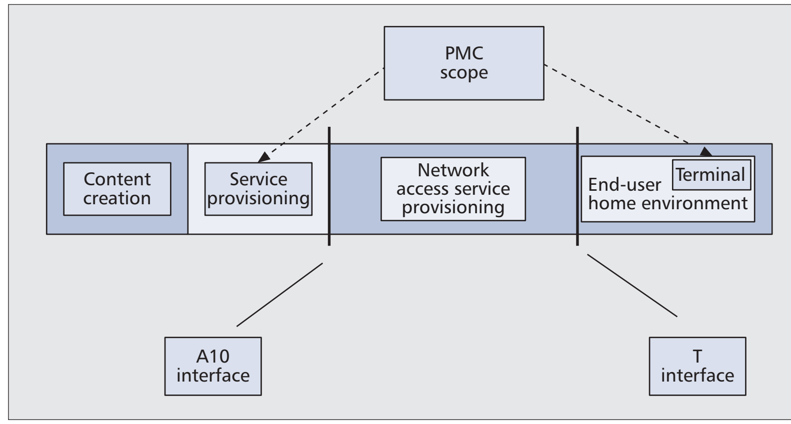

Figure 2. *MediaNet reference architecture.*

Residential Gateway

The residential gateway packs five modules, which carry out very different tasks. The layer 2 and 3 QoS marker and router maps the traffic classes according to home network QoS policies into the correspondent ones in the next segment, the access network. The UPnP IGD device provides some help to the NAT traversal function (e.g., by allowing some inbound port mapping to the PMC terminal for signaling or media). The application layer gateway (ALG), NAT, and firewall provide address translation and block dangerous traffic. The UPnP QoS policy holder and manager provide a UPnP interface for QoS management. Finally, the RGW DHCP server/client acts as a DHCP client regarding the NAP DHCP server, and as a DHCP server regarding the home network.

NAP

The NAP segment carries out its job through three different modules. The NAP network resource manager provides access network resources to the different ASPs; the NAP DHCP server authenticates the NAP subscriber and provides the RGW DHCP client the required network parameters, including public IP address, DNS server address, and ACS server address; finally, the role of the NAP auto configuration server is to provide the PMC ASP subscriber all the information relative to terminal management, not only for PMC terminals but for all types of terminals.

Additionally, this segment contains two additional modules in charge of providing support for security and billing: the NAP AAA N-service authenticates the PMC ASP subscriber, and the ASP charging server is in charge of NAP billing and charging functions.

PMC ASP

The core of the PMC ASP segment is the ASP PMC agent, which provides call logic and call control functions, typically maintaining call state for every call in the network. The signaling gateway plays the same role as the ASP PMC agent, but is placed at the border of a signaling network to implement the appropriate signaling interworking between the signaling architectures of the interconnected networks.

The service broker is the other main module of the PMC ASP segment. It provides service distribution, coordination, and control between application servers, media servers, call agents, and services that may exist on alternate technologies. The service broker allows a consistent repeatable approach for controlling applications in conjunction with their service data and media resources to enable services to be reused by other services to create new value added services.

There are two more modules directly related to the media layer. The media gateway provides media transformation between IP and time-division multiplexing (TDM) networks; it is also able to support some basic media services on the IP network (e.g., call tones); and the media server provides a full range of media services on an IP network. It enhances the set of services provided by media gateways adding conference, multimedia support, and so on.

Finally, there are other modules that offer support functionalities. The transport network resource manager (TNRM) interacts with the underling IP data plane to request the desired resource allocation. The session border controller (SBC) provides control of the media session between interconnected networks. The ASP AAA module provides AAA services for the users and calls managed in the PMC ASP segment. The subscription management server contains the user subscription profile, which includes service profile information. The AS holds the service logic for enhanced services that can be implemented in the PMC ASP segment. Finally, the service charging server manages the charging logistics related to activated PMC services.

End-to-End QoS Management in the PMC Architecture

This section explains how QoS management is carried out inside the PMC architecture, introducing the functional entities involved in the QoS negotiation.

In order to achieve end-to-end QoS management, the appropriate type and amount of resources shall be negotiated step by step through the network segments between the two endpoints. The resources are managed differently in each of the segments of the MediaNet reference architecture. A usual scenario is presented here, where the home network is a UPnP QoS system based on DiffServ and layer 2 priority domains, the access network is a DiffServ domain over layer 2, and the ASP network is a multiprotocol label switching (MPLS) domain.

To achieve the desired end-to-end QoS, a service level agreement (SLA) must be established between segments (subscribers, NAPs, and ASPs).

QoS management is based on flows and traffic classes, which are assigned a priority. The traffic class model shall be shared by all network segments (home, NAPs, and ASPs), meaning that all of them should consider the same QoS attributes (e.g., maximum jitter) for a defined traffic class. Because of the differences in the data plane of the network segments, the traffic classes should be properly mapped at data plane level in each segment.

QoS requirements shall be delivered and negotiated using the signaling protocols, and implemented in each segment at the data plane level as well.

Global Procedure

End-user terminals perform end-to-end negotiation of media and QoS attributes with the ASP using the service signaling protocol. The ASP initiates the traffic flow QoS admission and control: for its own segment it uses the TNRM, and for the access network segment the task is performed by the network resource management N-service interface. The end-user terminal initiates the traffic flow admission and QoS control for the home network with the help of the QoS manager.

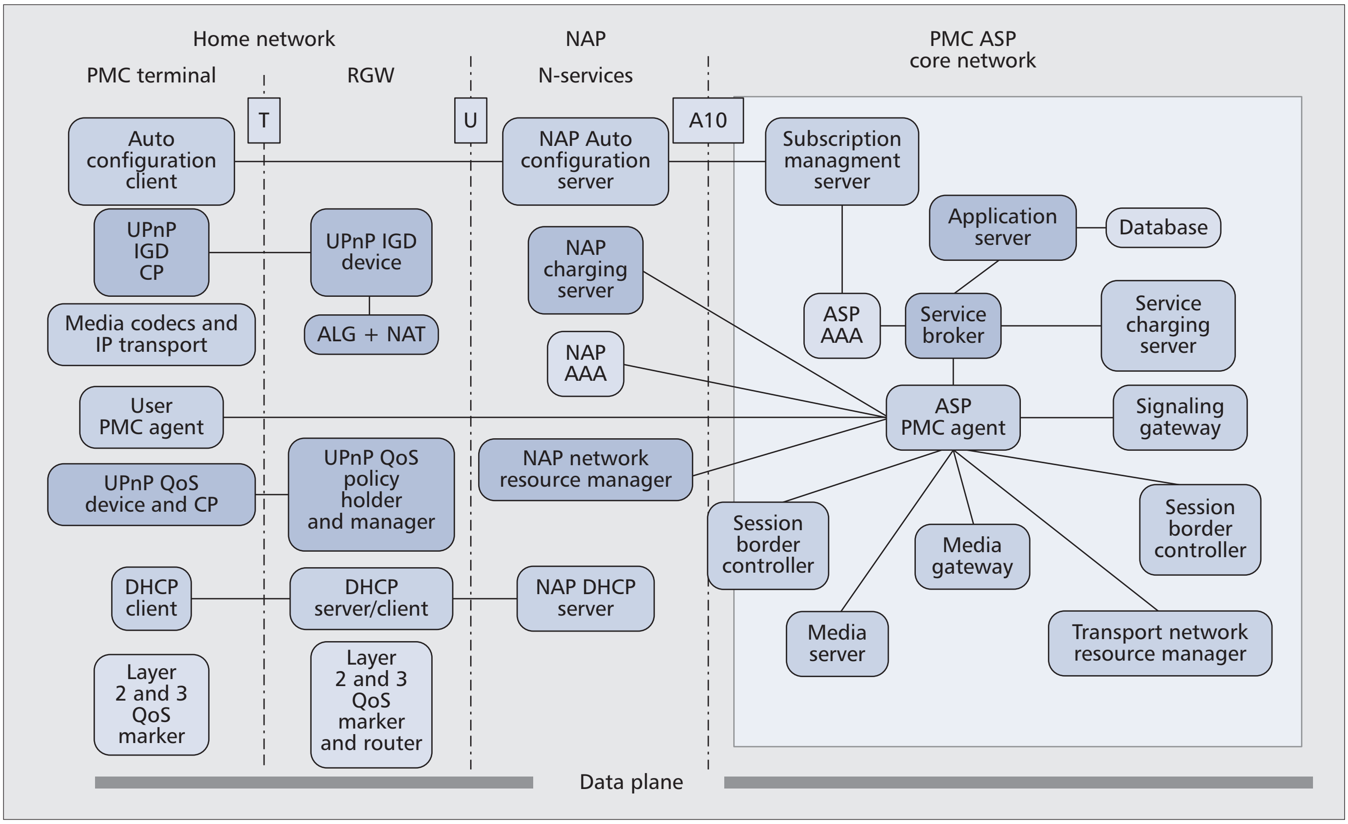

Figure 3. *MediaNet network description.*

Functional Entities Involved in the End-to-End QoS Model

The functional entities involved in the QoS management procedure described above are shown in Fig. 4.

At the data plane the only entity involved is the SBC, used for bandwidth management. The SBCs are able to monitor and eventually limit the bandwidth used by each media session. The hardware capabilities of SBCs can also be used for media ciphering. The SBC QoS management is controlled by a softswitch that acts as a policy decision point, while the SBC is the policy enforcement point.

At the control plane, however, there are quite a lot of entities involved. The ASP PMC agent performs an end-to-end negotiation of media and QoS attributes with the end-user terminals using service signaling. It also requests the QoS for traffic flows involved in the service admission and control from the TNRM and the NAP network resource manager.

The TNRM requests the routers and SBCs to admit traffic on demand of the PMC agent. The RGW hosts the home network QoS manager and the policy holder, and provides layer 3 and 2 routing, marking and queuing the ingoing and outgoing access network traffic.

The home QoS policy holder decides and defines the QoS policy to be applied to each traffic flow (e.g., the traffic class), while the home QoS manager requests of the home network policy holder the specific policy to be applied for each traffic flow, and asks each node on the traffic path to make admission and control operations at layer 2 and apply the policy regarding its priority at layers 3 and 2.

The home end-user terminal performs a threefold task. It negotiates, in an end-to-end way, media and QoS attributes with the ASP using service signaling. It requests admission and control for the traffic flows involved from the QoS manager. Finally, the QoS device, a home network device that is on the path of the traffic flow (e.g., RGW, wireless access points) provides or maintains layer 3 prioritization over layer 2, and may provide admission and control for its own network segment on behalf of the QoS manager.

Benefits of Using the MediaNet Model for PMC Services with Respect to IMS and TISPAN

The common view of future telecommunication systems seems to follow the direction of TISPAN and the IMS, which share a fundamental assumption: they consider an environment based on IP technology and mainly concentrate on the core network. TISPAN covers a wide range, while IMS is considered a component of the TISPAN architecture. However, the industrial world is looking at IMS with great interest. Moreover, IMS is well specified, while TISPAN seems still not mature enough.

The MediaNet PMC architecture considers a larger scope than IMS or TISPAN. There are some overlapping areas, but also a set of possible contributions to the standardization bodies can be identified. Some gaps have been identified in the IMS and TISPAN approaches that are solved in the MediaNet model.

First, it could be argued that the current diversity in terms of session protocols (SIP, H.323, MGCP, H.248, etc.), terminals, types of services, and applications will remain the same in the near future until the NGN infrastructure is completely adopted. An intermediate solution is well accepted. In MediaNet, convergence of signaling is proposed using SIP.

Second, the PMC service architecture must be defined in an end-to-end vision including terminal, home network, access network, and service provider, because the delivery of the service is strongly impacted by all elements of the chain. IMS and TISPAN consider the delivery of a PMC independent of the access network, whereas the MediaNet model envisages

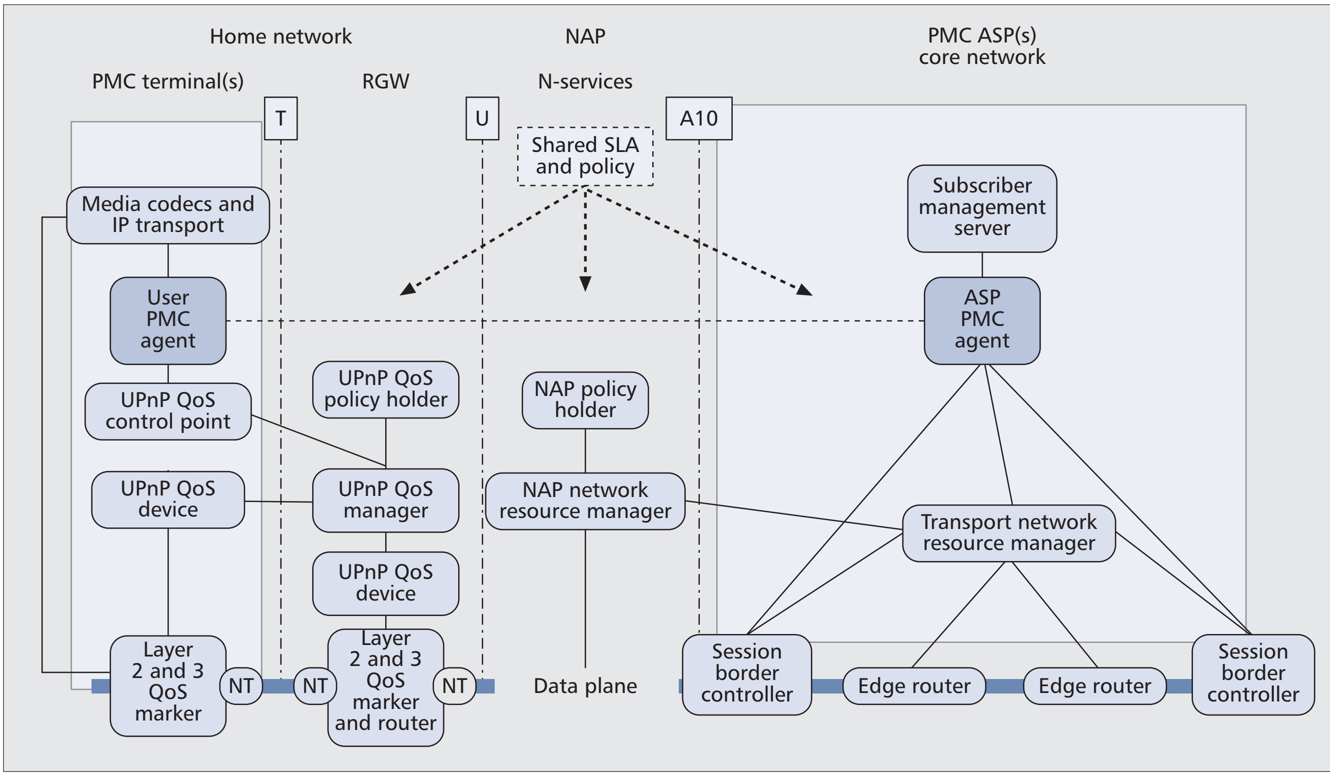

Figure 4. *Functional entities in MediaNet architecture.*

the whole value chain. Figure 5 shows a model of MediaNet representing the level of functionalities exposed: the application-specific level, which includes all the dedicated functions for the application; the shared platform level, which incorporates the functions that can be shared by applications of the same type, and belonging to either the same ASP or a service provider supplying several ASPs; and the common infrastructure level, which covers both the access and customer premises networks [15].

It could also be said that the PMC service infrastructure is not standalone. It may be aggregated with some other services by the access network. This aggregation represents the set of access network resources and infrastructure entities called N-service (e.g., billing and terminal management), with some other service providers. This aggregation concept is not considered currently in TISPAN or IMS.

Finally, it is worth noting that the TISPAN/IMS architecture is currently dealing with several issues related to

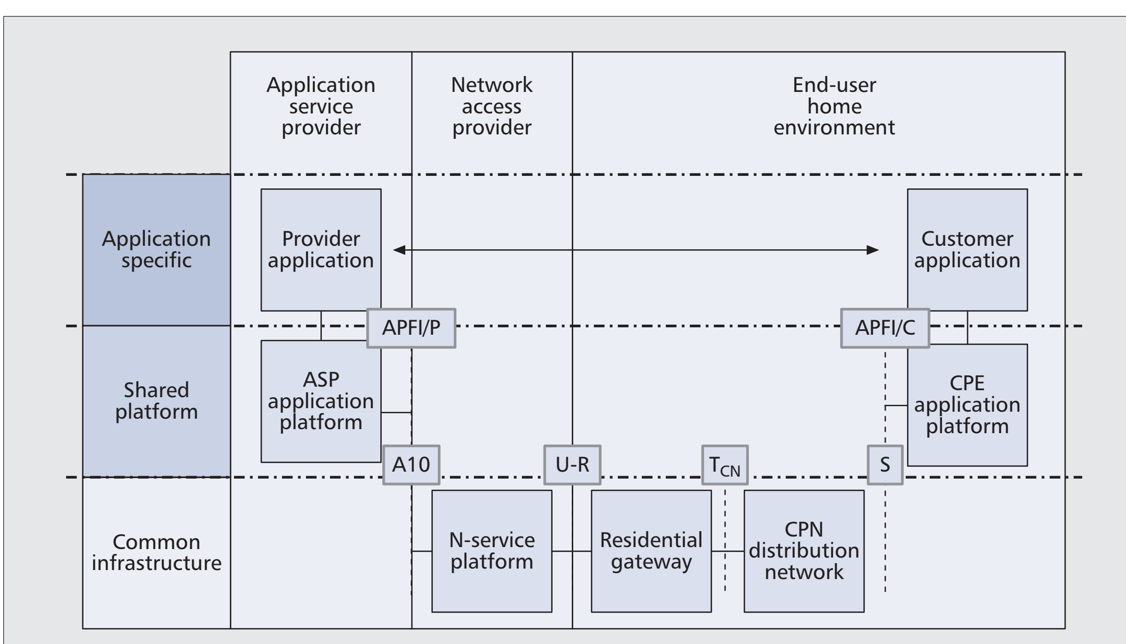

Figure 5. *MediaNet functional architecture.*

the access network and home infrastructure, such as QoS, NAT traversal, end-to-end security, terminal management, and terminal plug and play, which have already found solutions in the MediaNet infrastructure, as shown in previous sections.

Conclusions

One notable advantage of the MediaNet PMC proposed architecture is that it is immediately deployable and provides the enabling platform for evolution toward a full IP multimedia environment. The MediaNet network architecture is a valid choice for immediate update of currently deployed telecommunication networks. It has the advantage of preserving operator investments, providing the basis for smooth and fast evolution toward full NGN compliance.

The MediaNet network architecture is not limited to the core network. Its complete end-to-end view considers terminals, home, access, and core network segments. MediaNet brings many contributions to the home network environment, including terminal and access network services or N-services. Finally, the ASP core network segment is the glue to carry out a completely managed end-to-end service.

In summary, the results of this research work could be viewed as a set of roadmap guidelines that could support telco operators in the evolution of their networks and services toward the NGN. As the differences between MediaNet and IMS/TISPAN are mainly at the functionality level, further updates toward TISPAN or IMS could be carried out by means of simple software upgrades.

Acknowledgment

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