Convergent IPTV Services over IP Multimedia Subsystem

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***Abstract*—IP multimedia Subsystem (IMS) is one the most promising architectures for IP Television (IPTV). It proposes a common control plane achieving a certain service convergence and guaranteeing Quality of Service (QoS). The QoS issue is a major research challenge in NextTV4all, an ambitious project of the competitive pole Images&Réseaux in France that proposes a package of innovative services enriching audiovisual experience on both fixed and mobile devices over an IMS IPTV architecture as specified in standardization bodies such as ETSI TISPAN and 3GPP. In this paper, we present the main results of the project and describe the different activities that have been conducted from the service specification to the demonstrator development. Six innovative services are deployed such as the incoming call management and the chat room service that will be explained in detail in this paper. The paper ends with an outline of the QoS management in the IMS core and within the transport block.**

I. Introduction

The emergence of IMS [1] and IPTV [2] concepts has given the opportunity to conceive new services by combining traditional Telecommunication concepts and Internet service technologies. This gives another dimension to the multimedia contents usage. Indeed, the current users of these applications are looking to have more flexibility, more innovation and more robust services like interactive IPTV services, online gaming, undependably to the place and the terminal they are using. IMS is an architecture that is based on the SIP [3] protocol to establish sessions for users. To properly guarantee the QoS requirements, the providers using IMS negotiate the resource reservation before any data/flow transfer. Therefore, this architecture is suitable and especially appropriate for the video applications, which become the centric interest of the users.

Based on the flexibility and the relevance given by the IMS-based IPTV architecture, the French project NextTV4all [4] has elaborated six innovative services such as the incoming call management, where synchronization is established between the fixed terminal that receives the IPTV flow and the mobile that receives the call. This service as well as the chat room service will be explained in detail in next sections. For this, an architecture has been specified and a platform has been deployed. Furthermore, NextTV4all has particularly focused on the fixed/mobile networks and considers the heterogeneity of the access networks.

The remainder of this paper is organized as follows. Section III outlines the IPTV as well as IMS architectures. Section IV is dedicated to describe the NextTV4all project. This section ends with a detailed description of the implementation of two chosen services: the chat room and incoming call management services. Section V is dedicated to the GUI of the two chosen services. We conclude in Section VII.

II. IMS-based IPTV Architecture

In this section, we outline the IMS-based IPTV architecture and present its different components and procedures. IMS is an architecture that was initiated by 3GPP [1] and standardized by TISPAN. IPTV is the television of the future with the use of the Television over IP networks. Indeed, the current services are mainly focused on video content. The deployment of IMS functionalities enables to support interesting IPTV services such as session management, roaming and QoS control. IMS-based IPTV platform gives rise to the television of the future.

IMS is a control layer that interfaces the service layer and the transport layer by managing the sessions between the users and the application servers. This organization has two benefits: first, enabling the independence between the application server and the network, this will facilitate the development and the integration of applications servers. Second, the independence between the application server and the network is the basis for the fixed mobile network convergence. Hence a service can be available for the main access technologies and the service continuity is provided during the user's mobility phases. Developed initially by 3GPP, IMS has also been standardized by Telecoms and Internet converged Services and Protocols for Advanced Networks (TISPAN) and Open IPTV Forum (OIPF) to define an IPTV solution. Its different components and procedures are presented below.

Figure 1 shows an overview of the IMS architecture defined by TISPAN. The components of this architecture are:

The IMS Core : including the P-CSCF, S-CSCF and I-CSCF that route the SIP messages.

IPTV Service Control Functions : they are application servers that run the logic of each specific service (VoD, Live, PVR-).

IPTV Media Functions : including Media Control Functions and Media Delivery Functions that are in charge of delivering the media to the user.

Service Discovery and Selection Functions : they enable the user to discover the offered services and selects the ones he wants to access.

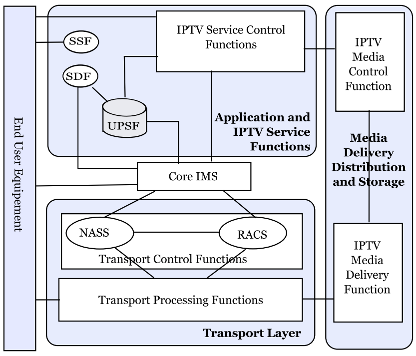

Fig. 1: IMS TISPAN architecture [5]

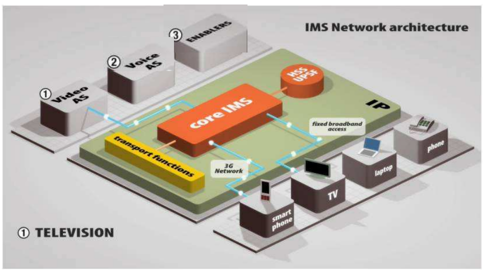

Fig. 2: NextTV4all platform

Transport Control Functions : include RACS (Resource and Admission Control subsystem), which controls how network resources are allocated to sessions and services and NASS (Network Attachment Subsystem).
User Profile Service Functions UPSF: stores information about the users account and their preferences.

III. NextTV4all Architecture

NextTV4all is an ambitious project that uses IMS IPTV architecture in order to implement enriched convergent services over fixed and mobile terminals. The principal advantage of using IMS is the mix audiovisual and communication services since both rely on the same architecture. Therefore, procedures like authentication and registering can be mutualized. The services of NextTV4all are chosen to enrich the user experience and show the possibilities offered by an audiovisual/communication convergence. Figure 2 describes the NextTV4all platform as well as its different components.

1) Components and Protocols : In NextTV4all, a Video Streaming server and 6 application servers (AS) are developed:
IPTV AS: which provides both Live and VoD Services.
Telephony AS: which provides VoIP services over IMS.
Reachability AS: which links the IPTV AS and the Telephony AS in order to mix audiovisual and communication services such as the chat room while visioning an IPTV program.
Presence AS: which provides the presence services to both contents and users.
Interactivity AS: which provides interactive services such as voting or quiz related to a visualised IPTV program.
Notification AS: which notifies the users for the beginning of an IPTV program and regional weather alerts.

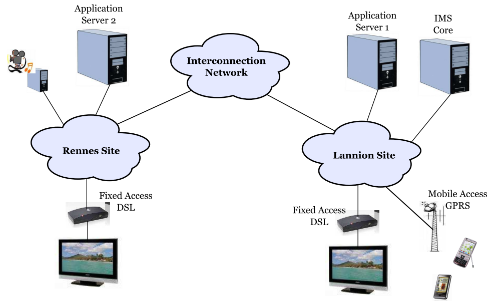

Fig. 3: Overview of the demonstrator architecture

These servers are deployed in a VPN Network over two distant sites as shown in Figure 3: a site at Lannion France and another one at Rennes France with ADSL and 3G accesses. The terminals that will be used for the demonstrator are a fixed Set-Top Box and three mobile terminals: HTC Dream with Google Android OS, Samsung Player Addict with Windows Mobile OS and Nokia N97 with Symbian OS. These servers are combined to propose six elaborated and high value services that will be presented in section IV.

The used protocols for signalization are: SIP (Session Initiation Protocol) for all the messages that transit through the IMS Core, Diameter: for the messages between the IMS Core and the Transport Control Functions and the UPSF, RTP (Real Time Transport Protocol) for the media transport, RTSP (Real Time Streaming Protocol) for the media control and the trick mode, and HTTP (Hyper Text Transfer Protocol) for the service selection.

2) Procedures: The user needs to access to an IPTV service. For that, the User Equipment (UE) contacts the Service Discovery Function (SDF) to ask for the Service Selection Function (SSF) address. The SSF contains the list of the proposed services. The UE contacts the SSF in order to choose a service (e.g. a live IPTV program or a VoD), it then sends a SIP INVITE to the SCF which runs the service logic and relays the request to the MCF, after checking that the user's registration allows the demanded service. If the user is allowed to the required service, the MFC contacts the RACS, which allocates the needed network resource in order to prevent network congestions and provide the user a good Quality of Service. Finally the MDF streams the media flow to the UE, which can directly control it rather than the IMS Core over RTSP. Note that the architecture described above are dedicated to fixed[1] usage.

IV. NextTV4all Services

Internet has deeply changed our habits in the past forty years. On one hand, the telecommunication providers introduced a new revolution in our multimedia content consumption, with the IPTV, which offers an uplink enabling interactive features like VoD and Time Shifting. IPTV is not only the

[1]3GPP defines a slightly different architecture for mobile access. In this architecture, only transport control and delivery functions are different from the ones defined by TISPAN to adapt to the mobile constraints.

broadcasting of TV programs over IP but also the possibility, called time shifting, to pause its reception when needed and continue it later on, and access to services as catch up TV and VoD. On the other hand, the IP Multimedia Subsystem (IMS) architecture has been designed to offer the convergence of fixed and mobile networks. The goal is the continuity of services when shifting from a network technology to another. This allows to watch IPTV programs on a TV set at home and then shift on a mobile device during mobility for example on the bus or the train. Furthermore, IMS aims at easing the multiplicity of services providers. For instance, it simplifies the interactions between routers and application provider servers.

Our main goals are to achieve service convergence between communication and audiovisual services as well as the mobile/fixe convergence. This convergence is illustrated by the six proposed services such as virtual chat room and incoming call management services.

As IMS proposes a common control plane for both fixed and mobile networks, which can be used for multimedia services, we chose to implement NextTV4all convergent services on IMS-based IPTV architecture.

Six services are designed and implemented on the NextTV4all demonstrator :

User Presence on IPTV service: this service gives the members of the same community the possibility to see each other's presence IPTV status. For instance, when a user is watching an IPTV program or VoD, he also can see what his community members are watching and even their location if they are using their mobile, without violating conformance with the privacy policies.

Program TV recommendation : this service is directly related to the previous one. Typically, when a user sees the presence status of a member of his community, he can recommend contents (IPTV Program or VoD) to this contact, if he is watching a different IPTV program.

Audiovisual interactive game : when some friends are watching the same IPTV program, they can simultaneously participate to a quiz related to this program. They can also vote to elect or save a candidate as it is done in many reality TV shows.

Notification service : this service can be very helpful for some catastrophe alerts. The users are alerted about storms, earthquakes, or child missing in their region. In another context, the user can set reminders to be notified for the beginning of an IPTV program or of the availability of a VoD. Note that this service is dedicated to the fixe/mobile convergence since the user can be alerted on his mobile as well as on his TV set.

Incoming call management : when a user is watching an IPTV program, his mobile calls are redirected on his TV set. Then, he can choose to answer, ignore or redirect the call to his voice messaging. In the case when a call is accepted, the program is interrupted and the call redirected to the TV set. At the end the program continue at the interrupted point. In addition to the convergence, this service requires interaction between the mobile and the TV set.

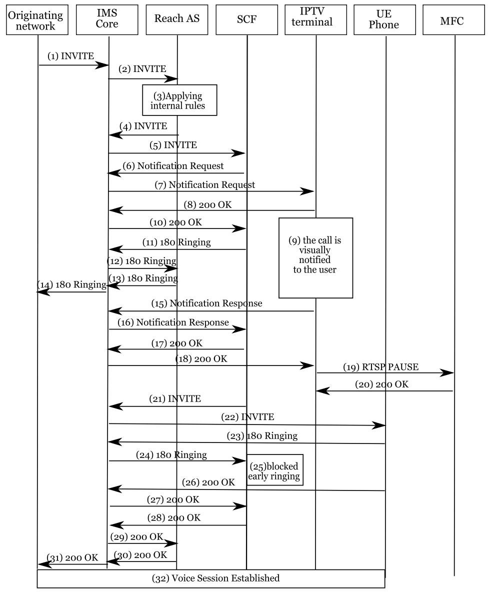

Fig. 4: Incoming Call Management Call Flow (accepted call)

Virtual chat room : As the program recommendation service, this service allows a community users that are watching the same IPTV program to discuss via instant messaging on their TV. The convergence fixe/mobile is an important issue of this service.

To detail the implementation of the presented services, we choose incoming call management and virtual chat room services, because they are the most global ones. For instance, the chat room service uses the presence service, and the incoming call management uses notification to inform a user that he receives a call.

A. Incoming Call Management and Chat Room Services Description

After the brief description of the six services that are deployed in NextTv4all, we propose to present with more details the incoming call management and chat room services. In this section, we mainly focus on the call flows exchanges to provide these services.

Incoming call management : a new function is required in order to enable a convergence between audiovisual and conversational services. This function is provided by the called Reachability AS, which connects the IPTV AS to the Telephony AS.

Figure 4 shows an incoming call management call flow, where the call is intercepted by the reachability AS and redirected to the IPTV AS, which notifies the called user on his TV set. The user can then choose between accepting the call or redirect it to his voice messenger.

Virtual chat room : the user can create his virtual chat room and invite other users to join him. Messages can then be broadcasted over the chat room and seen at the bottom of the screen.

This service induces particular QoS requirements; besides

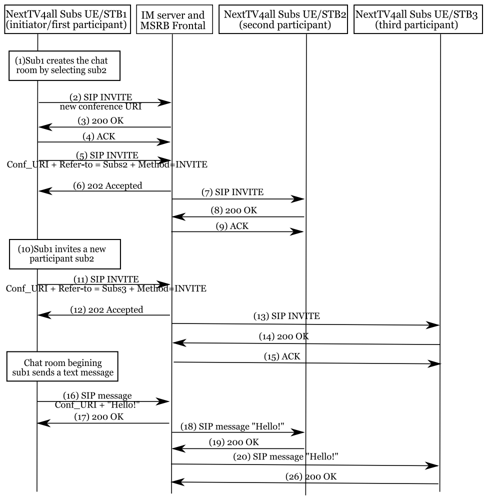

Fig. 5: Virtual Chat Room Call Flow

the bandwidth and the loss rate constraints that are inherent to any audiovisual service, all media and instant messaging flows have to be synchronized in order to provide an acceptable user experience. Figure 5 illustrates the different message exchanges between the platform entities before the establishment of the chatting session.

The UE initiating the chatting session contacts the Instant Messaging (IM) server. When this server accepts the request, the UE specifies the remote UE he wants to chat with, and chooses the communication method: text as well as voice. The IM server notifies the second UE of the invitation. If the invitation is accepted the chatting session begins and all exchanged messages transit through the Instant Messaging server.

After the implementation details, we present the GUI of these two services.

V. Users GUI for the Incoming Call Management and Chat Room Services

This section is dedicated to show the Graphic User Interface GUI of the NextTV4all services. However, it is complicated to summarize the different GUI components. For simplicity and without loss of generality, we choose the two above expressed services, and give an overview of the GUI user, when he is using these services.

Fig. 6: Incoming call management GUI

Figure 6 shows the user's window when he receives a call while watching an IPTV program. The program is then paused until the user decides to accept, reject or redirect the call to his voice messaging. If the call is accepted, at the end of the communication, the program is reset at the moment it was interrupted. The major advantage of this service is to give users flexibility and facilities to manage different devices like mobile, TV set and fixe phone.

Fig. 7: Chat room service GUI

Figure 7 illustrate a case when friends are watching the same IPTV program and want to exchange their comments about this program. They also can play a quiz together at the end of the program. If a friend is connected the user can suggest him to join his community and watch the same program as them. The main objective of such service is the conviviality and share between families and friends, and makes a common meeting at least virtually possible.

VI. QoS Management in IMS Core and Transport Block

The QoS provisioning is a centric issue to the deployment of the NextTV4all services. These services are deployed within the IMS-Based IPTV architecture, which are deployed in NGN networks. To guarantee a given level of QoS for a specific service class especially for real-time multimedia services, QoS management functionalities are integrated in NGNs. The QoS provisioning is generally divided in two typical techniques: the *avoidance of congestion* before any service is actually provided and the *congestion management* that accurate to correct the QoS level of a service that is already started. For the avoidance of congestion technique, the resource reservation can be negotiated and done by implementing a Connection Admission Control (CAC). Another solution for the avoidance of congestion, which can be expensive, is the over-dimensioning of network. This technique can also be used in Multiprotocol Label Switching (MPLS) networks by using the Resource ResrVation Protocol (RSVP) [6]. The management of congestion technique is based on differentiating the services levels and gives more QoS to the most important services as the marking of packets in Differentiated Services (DiffServ) protocol [7].

The QoS provisioning in NGNs is deployed within the architecture and by the interaction with the transport layer. Figure 8 summarizes the QoS management components.

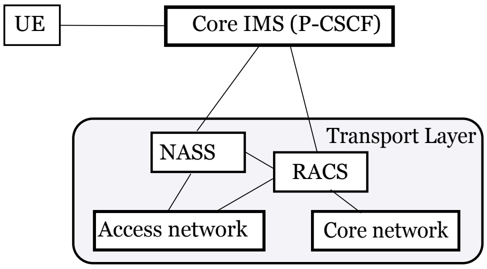

Fig. 8: QoS management in IMS and transport core

- **QoS in IMS core:** Before initiating a given session, the P-CSCF checks the resource required before establishing the session and negotiates with the user equipment to acceptable settings, by using the Session Initiation Protocol SIP requests [8].
- **QoS in Transport block:** The RACS is the main component that interacts with the access network as well as the core network that transports the service. More precisely, the RACS retrieves information relying to the network capabilities and decides to initiate the required service or not. When the service is already started, the RACS can influence the packets priorities by using the DiffServ protocol. It can also reserve resources with RSVP.

It is important to differentiate between negotiations of the QoS levels between the IMS core and the equipments, and QoS routing as done within transport block. The collected information by RACS translate the best routes satisfying the QoS requirements that can be offered by the network, if these routes are considered acceptable the related resources are reserved and then committed.

VII. Conclusion

The NextTV4all project has deployed various means to satisfy its customers. In this paper, we have presented this ambitious project that aims to provide Internet users a package of new services using an attractive simple and convivial interface. Furthermore, we have detailed the deployment of the chat room and incoming call management services over the IMS-based IPTV architecture. Indeed, IMS-based IPTV is the future of multimedia services over IP and the success of its deployment essentially depends on the provided network resources. In spite of the simulation results, NextTV4all project has deployed its prototype and all presented services are tested on this demonstrator.

Moreover, QoS is a central element in the provision of multimedia services within IMS IPTV architecture. Therefore, telcos have to focus on QoS provisioning and put in place mechanisms that could satisfy the demands of new multimedia real-time services such as visiophony.

To facilitate the comprehension of this paper, we summarize in Table I the signification of the used abbreviations.

Abreviation	Signification
IMS	IP Multimedia Subsystem
IPTV	IP Television
3GPP	3rd Generation Partnership Project
TISPAN	Telecommunications and Internet converged Services -and Protocols for Advanced Networking
OIPF	Open IPTV Forum
NGN	Next Generation Network
SIP	Session Initiation Protocol
P/I/S-CSCF	Proxy/Interrogating/Serving-Call/ -Session Control Function
SCF	Service Control Function
MDF	Media Delivery Function
SDF	Service Discovery Function
SSF	Service Selection Function
RACS	Resource and Admission Control Subsystem
UPSF	User Profile Service Function
AS	Application Server
RTP	Real-time Transport Protocol
RTSP	Real-Time Streaming Protocol
ADSL	Asymmetric Digital Subscriber Line
VPN	Virtual Private Network
HTTP	Hyper Text Transfer Protocol
UE	User Equipment
IM	Instant Messaging
GUI	Graphic User Interface

TABLE I: Abbreviations summary

VIII. Acknowledgments

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