Service and Control planes interaction in the VISION project

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Abstract. The emerging use of real-time multimedia applications exchanging 3D contents together with its associated strict quality of service (QoS) requirements imposes the redefinition of the networks. Within the Spanish-founded VISION project, new mechanisms for service and control planes interaction have been defined. In this paper we review these mechanisms which provide end-to-end IP services over integrated access, aggregation and optical core networks, with the requested QoS. We focus on the functionalities needed to provide dynamic resource reservation to the optical network.

Keywords: TISPAN, GMPLS, Optical-Resources Control, VISION project

1. Introduction

In the last years new personal communications systems have appeared, mostly based on the use of Internet. Nevertheless, people continue travelling to attend to meetings, since there is not any available communication system able to convey a real presence feeling; today's videoconferencing systems make people feel as talking to a machine.

The objective of the VISION project is to develop new technologies in the audiovisual communications field to allow connecting remote localizations. The resulting system should provide high quality 3D reality, making users to feel themselves at the same location. To this end, the VISION videoconferencing system should be able to reproduce real size, color and depth of the attendees by means of a multi-camera/microphone capture of the scene. In order to allow natural communications, the system requires both dynamically provided high bandwidth and very low latency. The VISION project is founded by the Spanish Ministry of Science. A group of 13 companies, and 12 universities and research centers participate in the project.

IP Multimedia Subsystem (IMS) is a set of requirements that illustrates the Next Generation Networking (NGN) architecture for implementing IP based telephony and multimedia services. It fills the gap between the two most successful communication paradigms, cellular and Internet technology. The IMS is an architectural framework for delivering IP multimedia services. It was originally designed by the wireless standards body 3rd Generation Partnership Project (3GPP) [1], as a part of the vision for evolving mobile networks beyond GSM. Its original formulation (3GPP R5) represented an approach to delivering "Internet services" over GPRS. This vision was later updated by requiring support of networks other than GPRS, such as Wireless LAN, CDMA2000 and copper-wired lines. To alleviate the integration with the Internet, IMS uses IETF protocols wherever possible e.g. Session Initiation Protocol (SIP) [2] a signaling protocol for Internet conferencing, telephony, presence, events notification and instant messaging.

The VISION network is based on the Telecommunications and Internet converging Services and Protocols for Advanced Networking (TISPAN) architecture for Next Generation Networks (NGN) [3]. NGN Release 1 adopted the 3GPP IMS standard for SIP-based applications, and also added further functional blocks and subsystems to handle non-SIP applications. NGN Release 2 added key elements to the NGN such as IPTV, Home Networks and devices. TISPAN IPTV specifications answer the emerging market needs such as triple-play and quadruple-play service offers.

Nevertheless, tomorrow’s applications will require an enhanced control layer to be supported, features that nowadays are not included in neither TISPAN (RACS reference) nor 3GPP (PCRF reference) guidelines. Services such as 3D presence, videoconference, on-line gaming will present really strict QoS requirements, not only regarding to very high bandwidth links, but also ultra-low delay and jitter. In addition, operators will not only have to meet these requirements in the access network, but also in the core network because the significant growing of the resources occupation in this area. The core is having an occupation level which makes to be worthy extending QoS control to this area, in order to do a more efficient use of its resources..

The VISION core network integrates and Automatically Switched Optical Network (ASON) [4] domain provided with a Generalized Multiprotocol Label Switching (GMPLS) control plane [5]. To create an integrated network, in the VISION project new modules have been defined to control optical resources, to aggregate IP flows in existing optical connections, and to requests for optical connection set up and teardown through an User-Network Interface (UNI) [6].

The remainder of the paper is organized as follows: section 2 defines the network architecture defined in the project. Section 3 presents the implementation of several modules and interfaces related with the optical core network. Section 4 describes how service layer and control layers coordinately work to provide dynamic resource reservation. Finally, in section 5 we draw the main conclusions of this work.

2. Network Architecture

The TISPAN model defines two management layers: the service layer and the transport control layer. In each layer, a set of subsystems connected through a number of interfaces are defined. The service layer of the VISION project includes the Core IP Multimedia Subsystem (IMS), while the control transport layer includes both, the Network Attachment Subsystem (NASS) and the Resource Admission Control Subsystem (RACS). The NASS module is in charge of the user authentication, authorization and IP connection provisioning, whereas the RACS module guaranties QoS on user-demand and as a function of the user’s profile during the initial attachment. Fig. 1

shows an example of the VISION network architecture where two IP networks are connected through an optical core network.

The RACS module in the TISPAN architecture specifies two modules [7]: The Service Policy Decision Function (SPDF) applies access policies to resource reservation requests, and flow policies to the user flows. The Access Resource Admission and Control Function (A-RACF) controls and manages access resources. It also receives QoS user profiles from the NASS module. IP edge nodes contain the Resource Control Enforcement Function (RCEF), which executes the flow policies under the control of the A-RACF module.

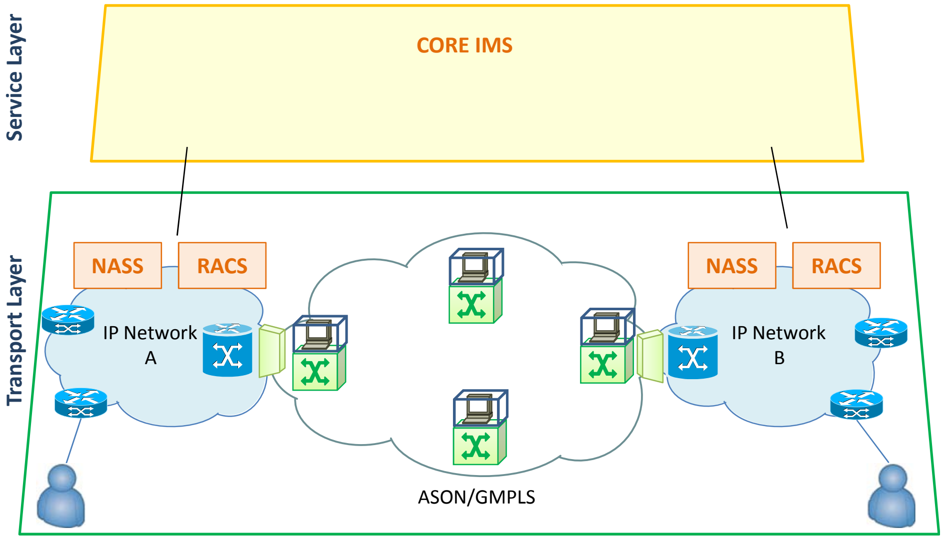

Fig. 1. VISION Network Architecture

TISPAN standards consider that the core network is over dimensioned, and QoS requirements should be fulfilled only in the access network. This assumption is only valid until certain extend, regarding that today’s applications only request a certain bandwidth value. Thus, the main problems which current services could bring with are bandwidth bottlenecks typically in the access network domain. With real time 3D applications, apart from a higher bandwidth, other requirements have to be considered, so that more selective parameters such as delay, latency or jitter should meet strict limits in order to provide a real presence sensation.

Related with the optical core network, a number of functionalities to provide dynamic resource reservation have been introduced. In fact, two new elements to integrate the optical core network in the TISPAN architecture have been defined: the Optical Core RACF (OC-RACF) receives IP resource reservation requests from the SPDF module, verifies reservation against the network operator policies, and communicates these requests to the Border Control Function (OC-BCF) module. The OC-BCF element is in charge of the optical resources in the optical aggregation node, mapping IP flows into optical connections. The OC-BCF module requests optical connection set up and teardown to the ASON/GMPLS domain through the UNI.

In addition, two new interfaces connecting these modules have been defined: the Rq' interface connects SPDF and OC-RACF modules, exchanging resource reservation, resource modification, resource release, and similar commands; the Re' interface connects OC-RACF and OC-BCF modules, exchanging optical resource management commands. Fig. 2 shows the modules and the interfaces related with the optical core network in the VISION architecture.

As an example of the set up of a new end-to-end session in the VISION architecture, Fig. 3 shows the needed signaling flow. When a user (e.g. USER A in Fig. 3) need to set up a new session with another user (USER B), sends a message to the service layer specifying the destination and a set of parameters (1). Then, the IMS requests resource reservation to the transport control sub-layer (2), belonging to the same network domain than the originating user. That message is received by the SPDF module which asks for resources availability to the OC-RACF module (3), and finally to the OC-BCF module (4). Upon the reception of optical resource availability, the SPDF asks for resources availability to the A-RACF module (5-6). Once the SPDF receives resource availability confirmation, sends it back to the IMS.

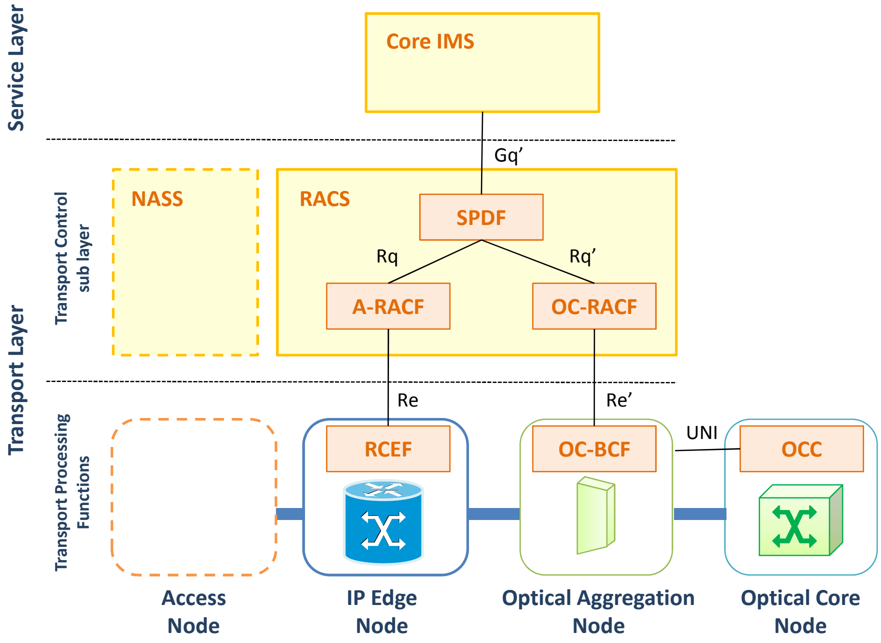

Fig. 2. Modules and interfaces at the Service and Transport layers of the VISION project

At this moment, the IMS starts a similar process in the network domain of the destination user (7-11), and finally, the IMS sends a message to the destination user asking for join to the session (12). When the destination user accepts, the IMS sends commands to allocate the resources; the OC-BCF requests for an optical connection in the ASON/GMPLS network through the UNI interface (13). Finally, the user session is set up and both users are connected.

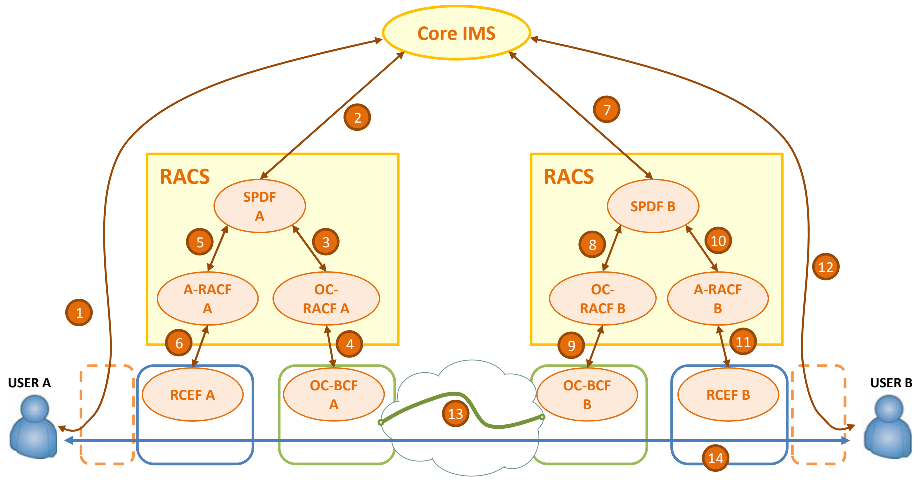

Fig. 3. Signaling flow for an end-to-end session set up

In the next section we describe the implementation of the Optical Core related modules (OC-RACF and OC-BCF) and their interfaces with the rest of modules.

3. OC Modules and Interfaces Implementation

The protocol used to exchange information among modules is Diameter [8] designed for Authentication, Authorization and Accounting (AAA). The Diameter protocol was commonly used in the IMS architecture for IMS entities to exchange AAA-related information. With the appearance of new technologies and applications such as wireless networks and mobile IPs, the requirements for authentication and authorization have greatly increased. The Diameter base protocol offers the following services: 1) connection and session management; 2) User authentication; 3) Reliable delivery of attribute value pairs (AVPs); 4) Agent supports for proxy, redirect, and relay servers; 5) Extensibility, through adding together new commands and AVPs; 6) Basic accounting services. Diameter sessions consist of exchange of commands and AVPs between authorized Diameter clients and servers.

Although the Diameter protocol specifies a set of Request/Answer command pairs, only a subset of commands have been defined to be used in the Re' and Rq' interfaces. Specifically, the commands defined in Table 1 have been implemented.

Using the commands defined in Table 1 resource reservation functionality can be implemented. Table 2 briefly shows the Diameter command flow used to reserve resources, modify a session, terminate a session, and notify events.

Table 1 Rq’ and Re’ Diameter commands and attributes

Commands	Attributes	Commands	Attributes
AA-Request (AAR)	Session-Id Policy-Component-Description Flow-Grouping	Session-Termination-Request (STR)	Session-Id Termination-Cause
	AF-Charging-Identifier SIP-Forking-Indication Specific-Action	Session-Termination-Answer (STA)	Session-Id Result-Code Experimental-Result
	User-Name Latching-Indication Reservation-Priority Globally-Unique-Address	Re-Auth- Request (RAR)	Session-Id Specific-Action Flows Abort-Cause
AA-Answer (AAA)	Session-Id Result-Code Experimental-Result Authorization-Lifetime	Re-Auth-Answer (RAA)	Session-Id Result-Code Experimental-Result Policy-Component-Description Flow-Grouping
Abort-Session-Request (ASR)	Session-Id Abort-Cause	Abort-Session-Answer (ASA)	Session-Id Result-Code Experimental-Result

Table 2 Rq’ and Re’ interfaces command flow for the complete functionality

Functionality	Command	Flow
Resource Reservation	AA-Request	SPDF -> OC-RACF -> OC-BCF
	AA-Answer	SPDF <- OC-RACF <- OC-BCF
Session Modification	AA-Request	SPDF -> OC-RACF -> OC-BCF
	AA-Answer	SPDF <- OC-RACF <- OC-BCF
Session Termination	Session-Termination-Request	SPDF -> OC-RACF -> OC-BCF
	Session-Termination-Answer	SPDF <- OC-RACF <- OC-BCF
Events notification	Re-Auth-Request	SPDF <- OC-RACF <- OC-BCF
	Abort-Session-Request	
	Re-Auth-Answer	SPDF -> OC-RACF -> OC-BCF
	Abort-Session-Answer	

Both OC-RACF and OC-BCF modules have been implemented as a multithread application in Java. The Re’ and Rq’ interfaces implementation are based on the JavaDiameterPeer API [9], an efficient Java implementation of the Diameter Base Protocol [8].

The OC-RACF module acts as a bidirectional proxy. On the downwards direction, it implements a Diameter server, receiving requests from the SPDF module through the Rq' interface, and also a Diameter client, forwarding authorized requests to the OC-BCF module through the Re' interface. In the opposite direction, it implements a Diameter server, receiving notifications from the OC-BCF module through the Re' interface, and also a Diameter client, forwarding notifications to the SPDF module through the Rq' interface. All Diameter messages are logged into an OC-RACF local database for further look up.

The OC-BCF module implements counterparts Diameter client and server for the Re' interface. It also implements a XML-based interface to convey requests to the underlying aggregation optical node.

4. TISPAN-to-GMPLS interconnection

As an example of TISPAN-to-GMPLS interconnection, in this section we review the resource reservation functionality for two alternative cases: the optical connection set up case, and the optical aggregation case.

When the OC-RACF module requests for optical resource reservation, it specifies IP source and destination addresses of the end users (denoted as IPA and IPB in Fig. 4), source and destination ports and required bandwidth. With this information, the OC-BCF module obtains, from the routing table, the IP source and destination addresses of the optical network end-points (denoted as IP1 and IP2). The OC-BCF has information about the already established optical connections and their unused bandwidth. Depending on the requested bandwidth, and on the available bandwidth of the optical connections with the same end-points, the OC-BCF module may decide to aggregate the requested connection to an existing optical connection, thus saving optical resources.

Let us assume that no optical connection exists between the optical network end-points. In such a case a new optical connection have to be set up in the GMPLS-controlled optical network, thus the OC-BCF module sends a request through the UNI interface. For the sake of clarity, we continue using the term optical connection instead of the Label Switched Path (LSP), more appropriated within the GMPLS terminology. Those requests include the end-points and the bandwidth. It is worth noting that, although the requested bandwidth is for the maximum available, e.g. 10Gbit/s, only the originally requested bandwidth is assigned, remaining the rest unused ready to be assigned to future client sessions. Additional information exchange, such as protocol, is under study.

After the new optical connection has been set up in the GMPLS domain, the two end OC-BCF modules are notified. The destination OC-BCF registers the new connection and sends a notification to the local OC-RACF about the new connection.

Aiming at better resource utilization, an important functionality of the OC-BCF module is the capability to provision sub-wavelength flows, packing several client low-speed traffic streams into higher-speed streams sharing an end-to-end optical connection.

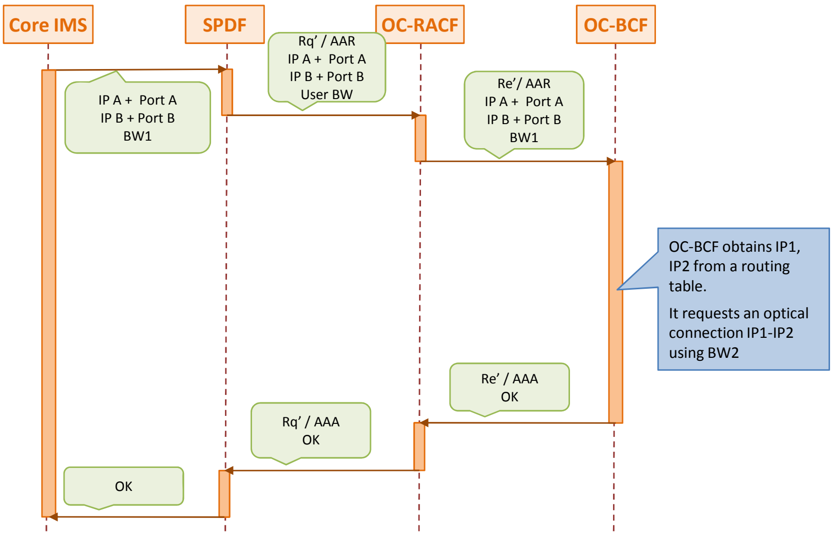

Fig. 4. Diameter signaling flow for an end-to-end session set up

5. Conclusions and future work

In this paper, the VISION project network architecture has been presented. Although the architecture is based on the TISPAN standard, some new modules and interfaces have been added. Specifically, two modules and interfaces related with the optical network have been defined and implemented to provide dynamic resource reservation: the OC-RACF and the OC-BCF modules and the Rq' and Re' interfaces.

An important issue in the VISION network is to provide end-to-end IP services over integrated access, aggregation and optical core networks. In this regard, two key functionalities have been presented in this work: firstly, the TISPAN-to-GMPLS interconnection to dynamically request optical connection set ups and teardowns, and secondly, the optical aggregation which provides better resource utilization.

Future work will be focused on developing new mechanisms for QoS in the optical core, so that the optical resources could be requested with specific conditions over the optical transport network, such as redundancy, used links, capacity, hops, specific optical path and so on, which will be defined. Advanced stateful QoS routing mechanisms are being also developed and the integration of these algorithms within GMPLS control plane is one of the objects of VISION project. Other functionalities like notifications and events related to failures in the optical network will be added, in order to have a better knowledge of its state in the upper layers of the system and in real time.

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