End-to-End Quality of Service Provisioning Through an Integrated Management System for Multimedia Content Delivery

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Abstract

Next generation networks will be complex, interconnecting different technologies and architectures (IP, DVB-T/S, UMTS, GSM/GPRS, etc.) across a multitude of software and hardware platforms for offering a large number of services (data, telephony, video streaming, videoconferencing, etc.). Consequently, one of the major requirements for the successful and wide deployment of such services is the efficient transmission of performance sensitive content (audio, video, and image) over a broad range of bandwidth-constrained wired/wireless access/core networks. This paper presents an approach to the management and provisioning of end-to-end Quality of Service (QoS) in next generation networks (IP and non-IP networks) that is being implemented in the IST ENTHRONE [2] project. The primary goal of this project is to provide a solution for seamless access to multimedia content with end-to-end QoS support through integrated management of content, networks and terminals. The adopted methodology in providing end-to-end QoS is to begin from service level agreements through to network resource allocation and provisioning for meeting the QoS requirements for multimedia content delivery and satisfying the customer QoS demands by including policy-based management, an integrated management supervisor and MPEG-21 / XML-based platforms.

Keywords: Integrated Management System (IMS), End-to-end QoS, MPEG-21, Diffserv,.DVB

1 Introduction

The Internet, is moving from being a simple monolithic data service network to a ubiquitous multi-service network in which different stakeholders (network providers (**NPs**), service providers (**SPs**), content providers (**CPs**), content consumers (**CCs**), etc.) require to inter-operate to offer value-added services and applications. These services and applications may dynamically be created and managed.

However, no complete and unified solution that enables the end-to-end delivery of services over various types of networks at a guaranteed quality level exists today. The problem has been and is currently being, investigated by many players in the field but only partial solutions have been proposed so far; the solutions provide end-to-end QoS only in special cases, e.g. for certain types of networks, for a single network operator, or for specific types of services. This problem is augmented by the presence of different actors (NP, SP, CP, CC), which makes it difficult to find a common strategy for QoS provisioning. The current practice in service offering is through the use of Service Level Agreements (**SLAs**). SLAs describe the characteristics of the service offering and the

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responsibilities of the parties involved for using/providing the offered service. The technical part of the SLA is the SLS (Service Level Specification) [1]. SLAs between services providers and consumer (**cSLAs**) are used to formulate the customer requests as well as customers' and providers' service commitments. Provider level service agreements (**pSLAs**) are between SPs and NPs and between NPs themselves that are supposed to lay the first stone for providers towards extending their geographical scope beyond their boundaries. This is the first challenge in offering inter-domain QoS delivery.

Developing a common framework to bridge the gap between stakeholders would facilitate cooperation and support a more efficient implementation and integration of the different needs and requirement for each one.

In this respect, **MPEG-21** aims to create the big picture of a common framework to guarantee interoperability by focusing on how the elements of a multimedia application infrastructure should relate, integrate, and interact. The MPEG-21 data model will be used to provide the common support for implementing the required functionality and managing the resources.

The provision of an Integrated Management System (IMS) for end-to-end QoS delivery across heterogeneous networks and terminals can be considered to be a key element in the successful mass market deployment of audio-visual services that would produce revenues for the content/service providers as well as network providers.

This paper presents the solution currently being developed and implemented in the ENTHRONE project for end-to-end QoS provisioning over heterogeneous networks. This solution aims to define open interfaces and contribute to the MPEG-21 standard, which will enable the interoperation of systems and equipment developed by different manufacturers and will help developers to adapt their products to be compatible with the end-to-end QoS concept. The approach taken by the project is based on a distributed model, where diversified QoS policy based management functions are performed in many geographically distributed environments (content generation, networks and terminals). A major goal of this project is to bridge the divide between the content provision and the networking worlds, resulting in cross-industry co-ordination on both network and content management issues, and bringing the focus to mutually advantageous standards such as MPEG-21.

This paper is organized as follows. Section 2 explains how the service requests are formulated and highlight the role of IMS for end-to-end QoS provisioning over heterogeneous networks. Section 3 describes the integrated metadata management by the ENTHORNE system. Section 4 presents in detail the networking infrastructure for end-to-end QoS delivery. Section 5 presents the overall networking infrastructure and the required protocols to be used in this networking environment. Finally, conclusions are presented in Section 6.

2 Service requests and IMS role

We proposes to allow the end-user select a service with a given or chosen quality of service, based on subscription to services either with published/well known SLAs, or dynamically negotiated SLAs. The service provisioning is accomplished using standardized service level specification, designed for DiffServ-enabled networks. The motivation for using SLAs and SLSs is to provide assured end-to-end quality of service to the end-user in a simple and efficient manner.

ENTHRONE proposes an Integrated Management System (**IMS**) architecture for managing service requests, service provisioning, multimedia content management using descriptive metadata, resource allocation, etc. that is implemented in a distributed manner encompassing the requirements of each entity/organization involved in service offering. As a consequence, the IMS will have a number of functional facilities/components for each entity/organization such as SP, CP, CC and NP. Therefore, the functional components listed below can be present or absent in each organization/entity, depending on the role of SP, CP, CC, and NP in the end-to-end service delivery chain.

The IMS provides a number of functional components:

- The **Content Manager** is responsible for keeping information related to the content, and to support all operations related to any subscriptions for the use of content, the management of and interaction with content.

- The **Terminal Device Manager** (**TDM**) is responsible for communication with the terminal device. It provides an interface to various kinds of terminals that provide actual service on the relevant domain. TDM also retrieves the Terminal Capabilities and the Network Characteristics of the network interfaces of the terminal, and passes this information to the IMS Dispatcher. TDM is also involved in tasks such as QoS Monitoring and License Handling, etc.
- The **IMS Dispatcher** and especially its Service Manager located at the service provider deals with the customer subscriptions (cSLAs), contracts with NPs (pSLSs), the services and the access to the service, which has been chosen. This is limited to the services owned by the SP. The Service Manager at the NPs deals with pSLSs [2]. In addition, it includes a metadata manager describing and handling the multimedia content. IMS Dispatcher also performs Digital Item Adaptation processing. An Adaptation Decision Engine (ADE) takes adaptation decisions with the goal of providing customers a service with the best quality given constraints on the terminal, the network and the cost of service.
- The **Network Manager** (**NM**) contains a facility for handling inter-domain issues in terms of QoS discovery, QoS-based route selection and the different types of QoS services that can be offered. The Network Manager has some knowledge of the resources and control layers, with the inter-domain vision for QoS service set-up in advance.
- The **Intra-domain Resource Manager** (**RM**) controls and manages the resources inside the domain to support QoS, and is technology-dependent.

Initially the SP establishes contracts (pSLAs like) with one or several CPs agreeing that the SP is allowed to offer delivery services for Digital Items to its customers. The SP is informed about the location(s) of the CP's Content Servers (CS) and all details of the services offered. The SP also is supposed to know (based on its traffic data delivered by its Service Planning functional block) the locations (regions) where groups of potential customers in the multi-domain network are placed. In our approach the SP decides to build one or several aggregated pipes (with reserved resources) from the content servers to content customer regions. A virtual network of such aggregated pipes (traffic trunks) is established in the inter-sdomain context. This is a key point in assuring our solution works in the Internet at large scale.

Prior to accepting any customer cSLA, the Service Provider, through its IMS Service Manager, will establish a set of QoS-enabled paths (aggregated pipes) between NPs based on contracts agreed between SP and NP, and between NPs. After the associated pipes (being the means for distributing contents from CPs to several destinations) are put in place, the SP can accept customer requests (cSLAs). After the network configurations are completed, the appropriate Network Manager, through the domain's Service Manager, sends an acknowledgement back to the IMS Service Manager of the Service Provider. From this point, the SP can offer services to customers/users.

It is assumed that a SP offers its services via a "Front-End" facility. In addition, it may advertise its services through a portal where a customer's request is redirected to the appropriate SP Front-End facility. The portal allows the user to select a service with a given or chosen quality of service. The IMS Dispatcher receives a cSLA (i.e., video on demand with gold service) from the front-end. After performing some initial checks and adaptation, it passes the adapted cSLA request to the Service Manager module of the IMS Dispatcher. The Service Manager translates the customer cSLA into SLSs taking into account the related metadata information and any adaptation decision made. After retrieving the service availability from an SLS repository, the Service Manager performs admission control to decide whether to accept or reject the request. SLS enforcement is achieved by means of a policy-based approach as explained in the next sections.

3 Metadata Management by the IMS Dispatcher

In order to provide users the transparent access to multimedia content with quality of service assurances, the IMS dispatcher component will use descriptive metadata describing the multimedia content itself and contextual metadata, providing descriptions concerning the content format and possible operations to be performed upon it for the adequate adaptation, such as the usage rights, the network, the terminal and the usage environment characteristics. While the content-descriptive metadata is fully addressed by MPEG-7 [3], [4][5], [6] and TV-Anytime [6] among other standards, contextual metadata is now being addressed by MPEG-21. In particular part 7 of the MPEG-21 standard – Digital Item Adaptation (DIA) [8]– specifies a set of tools clustered into eight major categories that enable to adapt content in order to provide the user the best possible experience under the available conditions. This includes respecting user preferences, terminal capabilities, network characteristics, conditions, natural environment characteristics, etc.

3.1 MPEG-21 Metadata

MPEG-21 specifies an abstract framework for a multimedia delivery chain, and as such provides mechanisms and tools to declare, use, modify, metadata and content. The fundamental unit of transaction in MPEG-21 is the Digital Item (DI) [9], [10] that is a structured object with a standard representation.

A DI contains multimedia content (resources in MPEG terminology), associated metadata, and structures representing relation between resources and metadata. REL (Right Expression Language) [11] in MPEG-21 is used to describe the permitted right associated with the DI. The DIA metadata is used to facilitate the adaptation of the DI.

3.2 Metadata Integration by the IMS Dispatcher

We can synthesize the integrated management of MPEG-21 metadata used in the our system with highlighting two distinctions: on one hand, from the dynamic perspective, metadata that are dynamically conveyed along with the digital content stream and metadata that are statically stored in local file systems or database management systems, and, on the other hand, from the contextual perspective, metadata that are content-dependent (or independent) or context-dependent.

Content-dependant metadata such as Dublin Core metadata elements [12], MPEG-7 descriptors, TV-AnyTime metadata and MPEG-21 DIA and IPMP (Intellectual Property Management Protocol) information can be conveyed along with the digital content in the bit stream (Figure 1).

Other content-independent metadata can also be added for enabling the processing of DIA and IPMP information; they include MPEG-21 DIA and IPMP tool lists and containers that are the necessary and specific programs for the adaptation and the

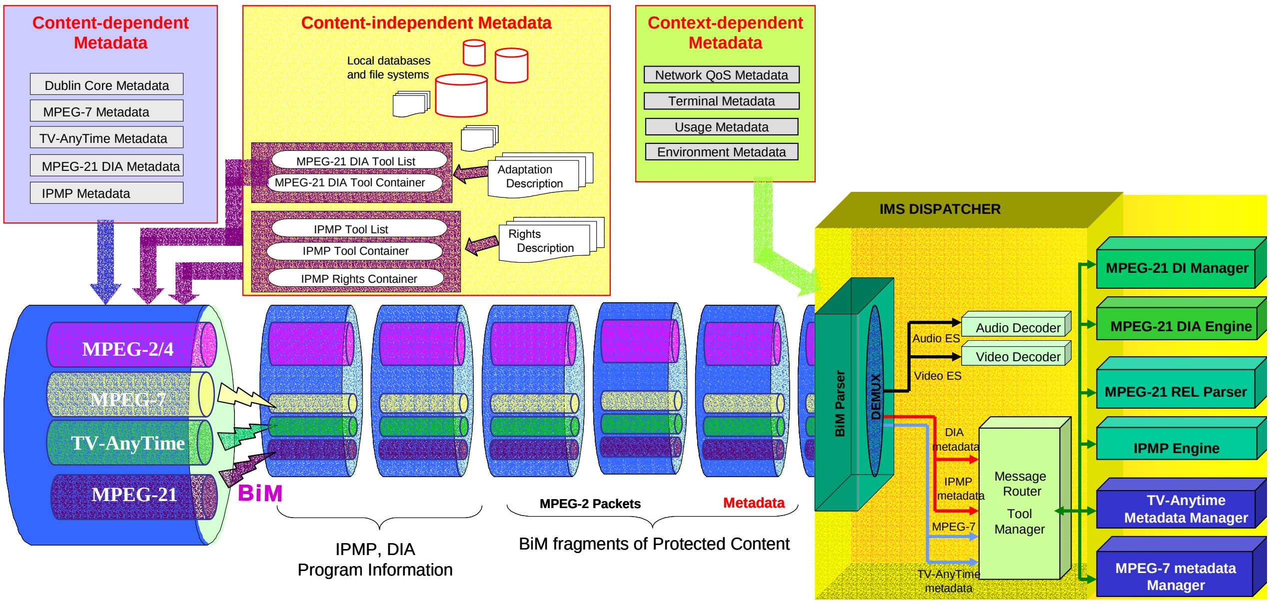


Figure 1: MPEG-21 Metadata Managed by the IMS Dispatcher.

intellectual property management and protection of the DIs. Conjointly, additional context-dependent metadata are collected through the participating network: they include network QoS metadata, terminal metadata, usage and environment metadata in MPEG-21 format. They are interpreted by the IMS dispatcher and sent to the DIA engine of the IMS for the adaptation processing. Context-dependent metadata comes from the network and the terminal device. The DI manager is a module of IMS and it includes all the operations related to the processing of MPEG-21 information.

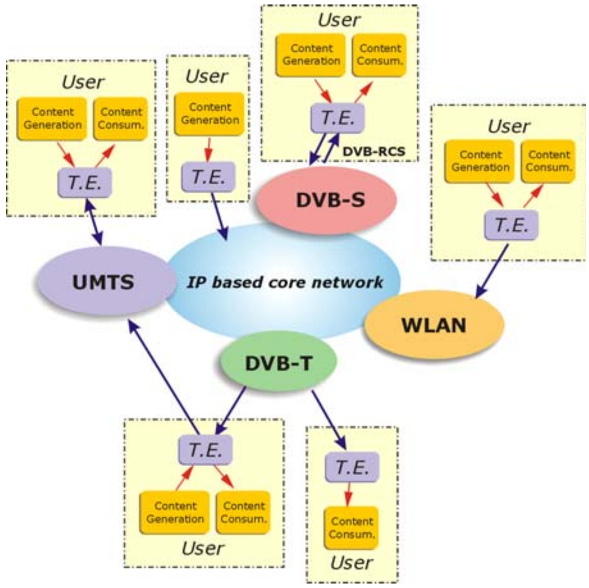
The format of metadata is XML encoded with BiM. The bit stream is divided up into several sections of two types: the first type of sections of the bit stream is dedicated to the processing including the specific programs to use for adaptation or IPMP, and the second type of sections of the bit stream is dedicated to the content (audio, video content and content-dependent metadata (among MPEG-7, TVA-AnyTime, Dublin Core elements, etc.). The IMS dispatcher receives the data and associated MPEG-21 metadata and sends Audio ES and Video ES to the appropriate decoders. The message tool router manager of the IMS dispatcher sends the DI, the DIA metadata, the REL metadata, the IPMP metadata and the content-descriptive metadata to the appropriate engines and managers available in the ENTHRONE subsystems.

4 End to End QoS Provisioning over Heterogeneous Networks

The end-to-end QoS provisioning issues in the ENTHRONE project are tackled at many levels; at the terminal level, the network level and the content level. The focus of this paper is on the network-level QoS.

Components of multi- domain QoS provisioning over heterogeneous networks should include a set of signaling protocols and functionalities among which are: (1) QoS-based level service specification for end-to-end service definition, (2) QoS-based resource allocation that allows the establishment of the end-to-end QoS-enabled path, and (3) QoS-based resource monitoring that monitors any degradation in the selected path/service. It is proposed that all these functionalities will be achieved through a set of end-to-end signaling protocols, namely the **EQoS** (End-to-End QoS Signaling Protocol), a suite of signaling protocols [13]. By using these signaling protocols, we seek to provide a unified service/management plane governed by the IMS, whilst allowing network technology specifics within the domain scope. An overall heterogeneous network architecture is described in [13], and [14] and is depicted in

Figure 2. It is envisaged that each domain in the multi-domain chain offers a distinct number of well-known QoS classes locally. That is, within a domain, all networking elements and intra-domain links, and border routers/gateways and their associated inter-domain links are engineered and provisioned for offering these QoS classes. The mapping and binding of these domain specific QoS classes can be achieved in order to offer end-to-end QoS classes across multiple domains. One solution in mapping/binding the QoS classes is to work towards a common understanding of application QoS needs.



T.E.: Terminal Equipment.
DVB-S: Digital Video Broadcasting-Satellite.
DVB-T: Digital Video Broadcasting-Terrestrial.
WLAN: Wireless Local Area Network.
UMTS: Universal Mobile Telecommunications System.

Figure 2: Overall Heterogeneous Network Configuration.

End-users use the same kind of applications in quite similar business contexts. Similar QoS requirements are likely to be requested by customers from their respective service providers. Providers are likely to define and deploy similar QoS classes locally, each of them being particularly designed to support applications of the same kind and with similar QoS performance constraints. These QoS classes can be extended end-to-end with mapping/binding of the similar classes achieved across the domains. Each local QoS Class can be extended end-to-end along the QoS class characteristics but to meet end-to-end requirement of some targeted applications. The related end-to-end performance values should be bounded in order not to exceed the target values suitable for the targeted application services. This means that the scope of the end-to-end QoS class may only be broadened within the application's end-to-end performance boundaries and constraints.

4.1 QoS Level Peering Arrangements

There are several models for the peering and service-level interactions between service/network providers for offering services across multiple domains. These models are for the support of inter-operator services for establishing a complete end-to-end service. They are strongly influenced by experience in the telecommunications industry of the provision of international telephony and other services for which network interconnection is a requirement, both in commercial and regulatory terms.

The type of inter-domain peering impacts the service negotiation procedures, the required signaling protocols, the QoS class mapping/binding and path selection [15]. Figure 3 shows two peering models.

- The **hub model** where the SP, as a distinct entity from NP, is the central point that negotiates and establishes provider-level SLSs with all individual NPs to be involved in the service chain.

- The **cascaded/bilateral model** where a SP and subsequent NP/s only negotiates provider-level SLSs with its immediate neighbouring provider(s) to construct an end-to-end QoS service. That is, only neighbouring domains establish provider-level SLSs between themselves.

It should be noted that each management system that manages a domain in terms of subscription and resource provisioning can be part of the distributed IMS (i.e., RM) or it can be de-coupled from the IMS but has the means to communicate with the IMS. We adopted the cascaded model, which gives better scalability properties [15] since SP does not need to have/maintain inter-domain topology knowledge.

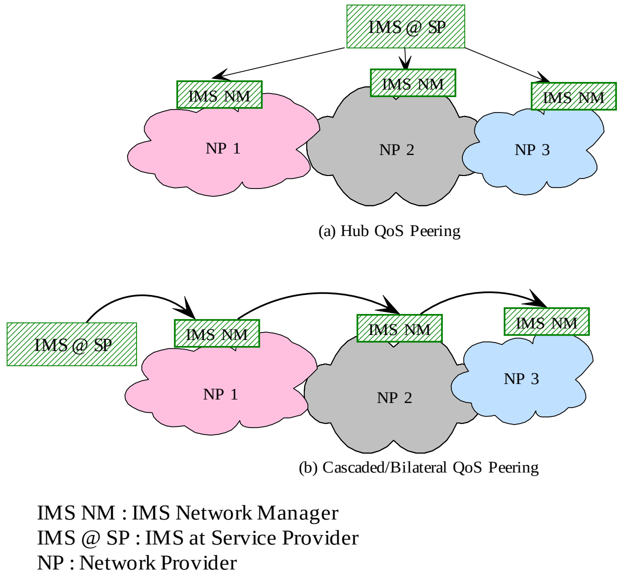


Figure 3: QoS Peering Models.

4.2 EQoS-Protocol Suite

We designed a protocol for SLA/SLS negotiation, which is part of the EQoS Protocol suite [13]. This **EQoS SLA/SLS** signaling protocol is used to achieve a form of Cascaded/Bilateral peering.

A service can be established end-to-end whenever the resources are provisioned and allocated accordingly. The resource allocation allows a particular stream or streams to consume particular network resources based on the contracted SLS. The actual traffic can use all or only a percentage out of the allocated resources. The EQoS protocol suite includes a resource allocation protocol (**EQoS RA**) which fulfills the required resource allocation functionalities across multiple domains.

QoS-based service and resource monitoring is essential to detect any service degradation and violations of the SLS agreements. A remedial function can be triggered to minimize the effect of service degradation. Such a function could be resource path renegotiations, path switching, traffic adaptation, etc. When traffic flows in a network, its actual resource use is monitored through the IMS distributed system entities and this monitoring may be shared with the IMS entity at the SP. The EQoS protocol suite includes a resource monitoring signaling protocol (**EQoS RM**) to implement this.

The functionalities of these protocols are discussed in the next sections.

5 Overall Networking Infrastructure

We adopted a four-plane based architecture as described below for provisioning end-to-end QoS over multiple networking domains/autonomous systems.

5.1 Physical Infrastructure

The Physical Plane includes the actual networking elements (e.g., terminals, servers, routers, switches, QoS capable multiplexers/encapsulators, etc.) that form part of the system infrastructure. These elements are grouped in domains/autonomous systems administered by a separate NP. Each NP employs its own networking technology (IP, DVB, etc.) and protocols for routing, traffic control, configuration, etc.

5.2 Data Plane

The minimum requirements imposed by ENTHRONE in this plane concern the support of mechanisms for service differentiation (e.g., the Diffserv technology for IP-based networks). Other technologies to support QoS control may be present such as using bandwidth management in DVB.

5.3 Control Plane

The Control Plane provides a one-to-one logical abstraction for all the networking elements of the physical plane using the corresponding PEPs (Policy Enforcement Points). Appropriate protocols (such as: SNMP, COPS or proprietary ones) are used to control these elements. The employment of an abstraction layer constitutes a usual practice in the literature for the external incorporation of advanced management functionality into heterogeneous networks [16].

The PEPs can be **ePEPs** (Edge PEPs) when they control edge devices or **cPEPs** (Core PEPs) when they refer to core network devices. The ePEPs and cPEPs have different functionality. ePEPs include appropriate agents for call admission (i.e., Admission Control Agent), for traffic control according the Diffserv architecture (i.e., Traffic Policy Agent) and for QoS monitoring (i.e., Monitoring Agent). cPEPs contain only Traffic Policy Agents. Furthermore, digital item (video and audio stream) adaptation can be achieved through a component called the TVM TV/Multimedia) processor that can be hosted in both ePEPs and cPEPs.

In IP-based networks, the classical BGP is essential for plain inter-domain routing. This may need to be extended for QoS-based route discovery and route assignment.

5.4 Management Plane

The Management Plane is composed of two sub-planes: the intra-domain management sub-plane and the inter-domain management sub-plane. The first one is responsible for the management coordination of all the PEPs that control a single domain. The second one is responsible for the communication of the management functionality among the heterogeneous autonomous domains. The management plane is implemented through PDPs (Policy Decision Points) and there is a one-to-one relationship among PDPs and autonomous systems or administrative domain. Along with the two sub-planes of the management plane, each PDP can be separated into two administrative modules, namely: (1) a Resource Manager (RM), , and (2) a network manager (NM) for handling inter-domain QoS issues. It should be noted that the network configurations through PDP and PEP is only considered when the distributed IMS is responsible for the network provisioning and allocation.

The IMS Network Manager (NM) provides a homogeneous end-to-end view of the service for multiple domain heterogeneous networking. In general, the interface between the NM and RM defines the exchanged functionality between the IMS and domain-specific technology. This open interface is currently being standardized under the MPEG-21 Working Group. Note that an autonomous system that participates in the ENTHRONE environment may implement its own resource management functionalities. The IMS NM has to communicate directly with this module through the appropriate interface. The RM manages the PEPs of its own domain. It may contain functional element such Admission Control Manager, Traffic Policy Manager and Intra-domain Network Monitoring Manager (Figure 4). The Admission Control Manager sets up and manages the admission decisions of a particular stream. The Traffic Policy Manager provides a simple, automatic method for network administration and configuration. Instead of manually configuring the network, the network administrator can run the Traffic Policy Manager to continuously sense and set up network parameters. The Intra-domain Network Monitoring Manager is responsible for aggregating monitoring information and making it readable to the IMS. All these modules correspond to the respective agents of the corresponding PEPs.

The communication between RM and ePEP/cPEPs can be performed through a set of signaling protocols based on SNMP, COPS, or CLI.

5.5 Service Plane

The Service Plane is responsible for the establishment of the SLAs/SLSs among the providers and/or consumers that participate in the ENTHRONE infrastructure. The appropriate EQoS signaling protocol (**EQoS SLS**) is used for SLA/SLS negotiation.

Figure 4 depicts the functional entities involved in the end-to-end QoS provisioning over heterogeneous networks.

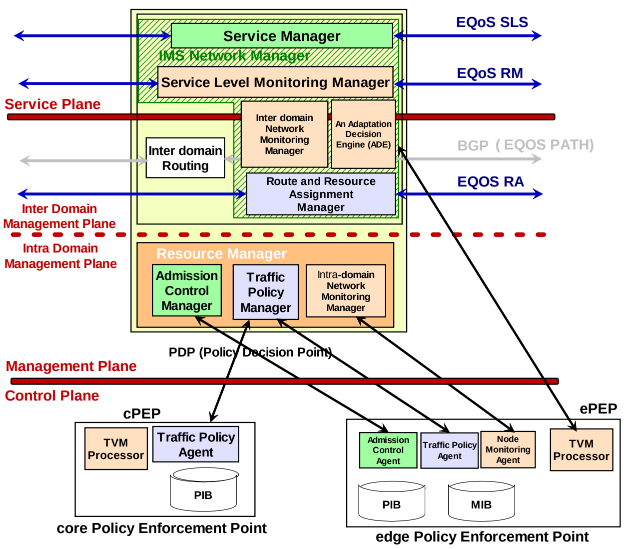


Figure 4: High Level Functional Architecture.

5.6 QoS-based Signaling Protocol for SLS Negotiation and Subscription

The customer formulates its request for service subscription and communicates with SP through SP-FE (Font-End). EQoS-SLA is used for this type of negotiation. The pSLS subscription is a commitment on resource usage for user traffic. This happens between SP and NPs and between NPs. It allows NPs to dimension and provision their network appropriately and to allocate their resources according to customer requests and future demands. This resource provisioning and allocation can happen either off-line during the network provisioning cycles or may be adjusted dynamically on demand. These reservation requests should not occur frequently as they may disrupt the services currently being provided. For provider level service negotiation, we designed a signaling/negotiation protocol named in this context EQoS SLS. It can provide simple request / response mechanism with a set of messages generically presented here as follows:

- *EQoS SLS Request*: this message is the customer/provider request for a service based on an SLS (cSLS, pSLS) from a provider.
- *EQoS SLS Response:* this message indicates whether the requested SLS can be fulfilled or not. This may trigger further negotiation. EQoS SLS Request and Response happens in horizontal direction.

Figure 5 shows a simplified sequence of pSLS agreements between providers and cSLA agreement between customer and SP .

The signaling/negotiation protocol that is developed in the project is more complex, as it covers both SLA and SLS negotiation (EQoS-SLA/SLS-NP, [13][2]) allowing not only request/response dialogues as described above, but also more complex negotiations is handled.

With respect to negotiation features offered, the EQoS-SLA/SLS-NP is comparable to other negotiation oriented protocols like SrNP, [17], or COPS-SLS, [18] but it is more adapted to the system context and needs.

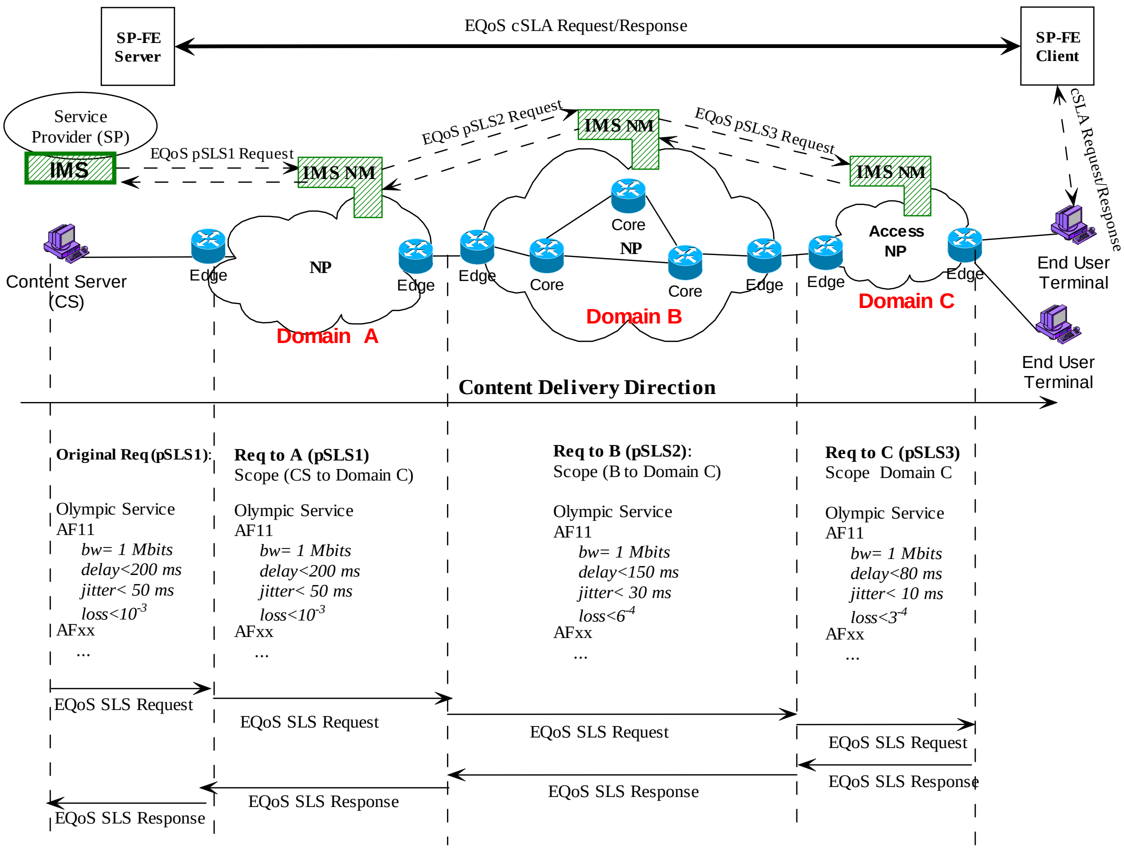


Figure 5: Service Level Specification Signaling Protocol.

The EQoS-SLA/SLS-NP is a client-server half-duplex negotiation protocol between two negotiation entities. It functionality includes: setup a new/ modification/ deletion of an SLA/SLS contract. The basic two-steps negotiation session is of type "proposal followed by yes/no_answer", started with a client proposal and then, server accepting or rejecting it. More complex several steps negotiation session can start with an initial proposal from the client, revision returned by the server, another proposal from the client and so on, up to the termination of the negotiation. Several variants (alternatives) of negotiated objects values and selective acceptance or rejection of different alternatives are possible. The conclusion of contract can be optionally delayed (negotiation session, started, interrupted and resumed later). This feature could be useful for a better service of requests arriving sequentially to server when the latter is not able to serve immediately a request. More details are presented in [2].

5.7 QoS-based Resource Allocation Protocol

A pSLS chain is established during the pSLS subscription for specific QoS class. This chain can be from the point where the contents are located to a destination domain where an appropriate number of customers are located. The scope can be from the source domain (e.g., a router interface) to the ingress/egress point of the destination domain. Once, the pSLS chain is established and the resources are promised by the appropriate domains and during the pSLS invocation phase, the EQoS-RA protocol is run across domains in cascaded fashion in order to request for allocation of resources. The EQoS-RA is a **data-path decoupled**, **out-of band** signaling protocol, running between managers, i.e. it is not like RSVP protocol. The inter-domain resource allocation is accomplished at the pSLS aggregated level. This approach is important because it assures the scalability of our solution, by avoiding per-call signaling in inter-domain area. Some generic messages of this protocol can be:

- EQoS RA Reservation Request: this message is from upstream domain to downstream domain for requesting allocation of the promised resources,(or a percentage of them).

- EQoS RA Response: this message is a response of the request message to indicate success/failure of the allocation. This message is sent from downstream to upstream domain and finally to SP

The actual allocation implies vertical signaling actions between the domain Resource Manager (RM) to networking devices in order to install the appropriate configuration in Data Plane DiffServ entities (policers, meters, buffer management, schedulers) in IP environment and multiplexers in DVB environment. Furthermore, delivering QoS guarantees requires controlling the amount of traffic entering the network. Therefore, appropriate information regarding the SLSs is given to be used by the domains for admission control and traffic conditioning purposes.

When the pSLSs are realized and their resources are allocated, then the SP can accept cSLA from customers, for individual subscription to some selected services (from a list offered by SP) with a given level of QoS. This means that SP deals with any cSLA requests and based on its prior knowledge of pSLSs installed it can accept or reject the requests.

At individual service invocation time the SP establishes a cSLS with the first NP situated at the entrance of the pSLS pipe, in order for allowing the individual customer traffic to use the resources. The resources are already in place on the pSLS pipe. The only allocation which remains to be made at the time of invocation is on the peripheral segments of the chain (e.g. Customer Access Network).

No signaling for this service invocation is needed between the NPs but only between CC/SP and CC/CS. Therefore the solution is scalable. A disadvantage of this approach (price paid for avoiding inter-domain signaling on per-flow basis) is that the only mean for a transit NP to know about the current usage of its big pipes is the monitoring. Detailed analysis of such situations and possible solutions will be performed during the progress of the project.

Note that each IMS distributed entity may aggregate several allocation requests in a single message. This can dramatically reduces the amount of requests between two domain peers and provides more scalability.

5.8 QoS-based Resource Monitoring Protocol

Monitoring information can be used for network provisioning, dynamic resource allocation, route management and in-service performance verification for value-added IP services. Here, a Resource Monitor always runs in each domain for delay, loss, and throughput measurements. The user traffic can be adapted during periods of congestion. The Resource Monitor will locate the domain that is violating the agreed SLS if any degradation of end-to-end service occurs. If a domain fails to meet its contractual obligation, the Resource Monitor informs this violation to the IMS. The IMS instructs the source to take remedial action or may apply a local adaptation. All these signaling mechanisms are carried by a set of messages described in EQoS Resource Monitoring (RM) signaling Protocol, which is currently under investigation in the ENTHRONE project. However, this inter-domain level monitoring is subject to establishing appropriate agreements between providers that allows a provider to retrieve monitoring information form other provider's respective domain/s.

6 Conclusion

In this paper, we have described a distributed management approach for providing end-to-end quality of service over heterogeneous networks. In addition to IP networks, service differentiation can also be implemented in non-IP networks such as DVB. Adopting a policy-based network management solution allows an independent management/control plane that can inter-operate with data planes consisting of multi-vendor networking platforms. In providing a QoS-enabled inter-domain networking infrastructure, a QoS-based signaling protocol suite is used for SLS subscription, resource allocation and monitoring purposes. In summary, we believe that the presented approach is scalable and can contribute towards operationally optimized networks that can support the Integrated Management Supervisor (IMS) in offering the QoS-based services to a large number of customers.

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