ALPHA: Proposal of Mapping QoS Parameters between UPnP Home Network and GMPLS Access

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Abstract. This paper is treating the interdomain QoS signaling between the home and access domains with a focus on applying it for providing QoS between a UPnP-QoS based home network and GMPLS based access network. The work presented here is defining a possible approach for an interface between UPnP-QoS and GMPLS in order to move towards end-to-end QoS establishment as well as investigating the complexity of such a solution. We present the QoS parameters and mechanisms in both UPnP-QoS and GMPLS and how they can be matched to create a coherent QoS architecture.

Keywords: Interdomain QoS, UPnP-QoS, GMPLS, Auto-Discovery and Auto-Configuration of end-systems and access devices.

1 Introduction

Home networks and network services available for residential users are under a constant development. The integration of services is becoming a reality and lately much attention has been attracted by triple-play services. One of the requirements for quality delivery of triple-play services over a single broadband connection is the possibility to differentiate between the services as well as providing end-to-end QoS. The means for guaranteeing QoS within different domains usually are different. In this paper we consider the two areas that are ICT ALPHA project's main focus i.e. home- and access networks. In the home network domain we consider a service based architecture for further analysis. In this paper we describe the UPnP-QoS Architecture [1] as a control and management protocol. We examine the suitability of UPnP-QoS for the management of a modern home network and we consider an implementation of UPnP-QoS version 3. UPnP-QoS defines the approach for providing QoS as an application layer management protocol, it does not define any actual means of mapping policy based priorities into link/network layer technologies such as Ethernet or WiFi. This allows more flexibility and leaves the decision about the marking

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for the network implementers. In this paper we will focus on the edge between the home and access networks and mapping parameters signaled by UPnP-QoS components to the QoS scheme used in the access network.

As an access network technology we consider a packet based Active Optical Network (AON) e.g. based on Ethernet or MPLS. In the scope of AON network we investigate the GMPLS protocol suite using OSPF-TE for routing and RSVP-TE as its resource reservation protocol. MPLS and GMPLS are often seen as core technologies, but during recent years MPLS usage has been pushed towards the end-customers and is commonly referred to as "MPLS access". This together with the common belief that future broadband access should be viewed as the "fourth utility" and the future need for higher bandwidth in this part of the network then GMPLS is a possible future control plane due to its traffic engineering and multi-technology data plane support (e.g. high capacity optical networks).

The use-case that is motivation for a discussion in this paper is depicted in Fig. 1. Integration of the QoS provisioning in the home and access networks allows preservation of the flow transmission parameters, like delay, jitter and data loss, between the host in the home and server in the access network, e.g. preventing above listed traffic flow parameters from degradation due to background traffic (like in Fig. 1 the solid line - Video on Demand service being protected from the dashed line - background traffic).

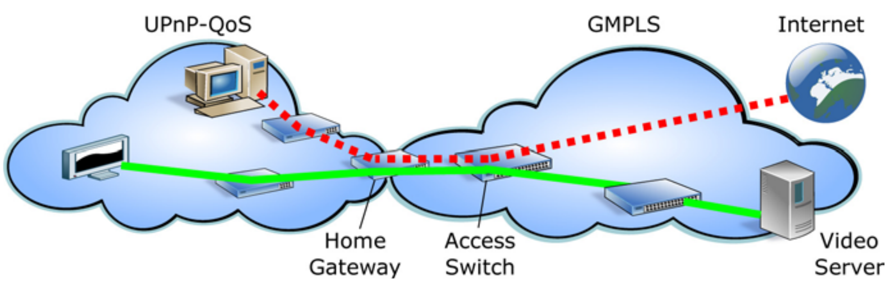

Fig. 1. UPnP-GMPLS usecase

Proposing a control and management plane interface between the UPnP network and GMPLS network is an important step towards the integration of these two, what we think, important technologies in home and access networks respectively. The integration of QoS within these domains would allow end-to-end QoS provisioning for services that are provided by the access network operator or services where the operator has direct connectivity with an external service provider - which might be a common case). End-to-end service that traverse more domains, e.g. the entire Internet, are out of scope.

In this paper we usually refer to mapping as to the translation of the QoS parameters from one domain to other neighboring domain (that we can call also horizontal mapping), to distinguish the mapping performed between different OSI layer in the same domain (usually in the same network component) we will refer to this mapping as *vertical mapping*.

Related Work

The authors of [2] recognize the need for QoS information exchange between home and access network, but propose to “outsource” the flow classification to the access network. They correctly claim that use of RSVP imposes limitation like; *"applications need to be specially (re)written; the approach is not scalable as routers need to track resource requests and usage of multiple independent flows; typical consumer access routers are low-power devices and potentially lack the resources to implement this solutions"* [2]. Our solution does not require redirecting a copy of all customer traffic to a centralized classifier and additionally users equipment needs to be only UPnP-QoS enabled (which is an extension to already widely deployed on personal devices UPnP). When scalability is considered, in our scenario a few, quality sensitive, applications do need to support UPnP-QoS and scalability is not of great concern as scenario described does not consider global end-to-end reservations but is limited to smaller domains designed to meet scalability requirements. Additionally, we do not necessarily have a 1:1 relationship between application flows and network reservations i.e. application flows can be merged into a single reservation thus reducing the amount of signaling state.

An investigation of end-to-end QoS establishment and some work on integration of reservations is presented in [3] where the authors use SIP information to discover the domains to request QoS in. The authors however do not present how specific QoS parameters like bandwidth, delay, etc. are signaled in different domains.

This paper contributes with the first, to our knowledge, QoS mapping and signaling schema between a UPnP-QoS based home network and a GMPLS based access network. It outlines the design part that later on enables an implementation and verification phase. Design, implementation and verification of such an interface are included as FP7 ICT Alpha goals.

The remainder of this paper is organized as follows; section 2 treats UPnP-QoS, section 3 describes QoS approaches in GMPLS. These sections are followed by mapping strategies in section 4, finally in section 5 the conclusions are given.

2 In Home QoS - UPnP-QoS

The UPnP-QoS Architecture [1] defines a number of services responsible for QoS provisioning in the home network. There are four distinct components in the UPnP QoS Architecture, these can be seen in the overview of the architecture in Fig. 2. The Control Point (CP) is the entity that requests QoS for a traffic flow (typically it is part of an application that is the traffic source), it is aware of the requirements of the traffic flow, its source- and destination address. The QoS Manager (QM) is the entity responsible for QoS establishment; it contacts the QoS Policy Holder (QPH) to obtain the policies that should be enforced for particular traffic flows, it also monitors the state of and requests the admittance of a traffic on the QoS Devices (QD) along the calculated network path.

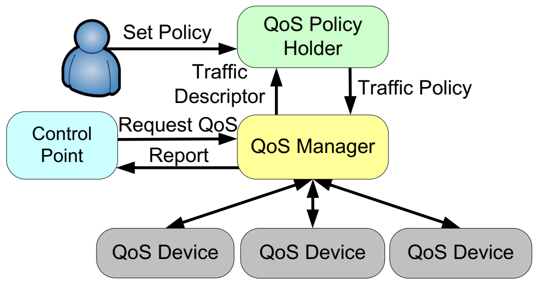

Fig. 2. UPnP architecture

UPnP-QoS defines three types of QoS: prioritized, parameterized, and a hybrid. QoS types UPnP-QoS uses different parts of the Traffic Descriptor [1] for defining the requirements towards devices' capabilities and configurations. In subsections below we describe the Traffic Descriptor parameters for prioritized and parameterized QoS. Later in the section 4 we will discuss the tasks of mapping the parameters conveyed by the Traffic Descriptor to the interface proposed in this paper, specifying the input for the establishment of the resource reservations in the access networks.

2.1 Prioritized QoS in UPnP

Traffic prioritization usually gives good results in preservation of transmission parameters of different flows types, although only when there is no oversubscription within the priority classes. It is performed by marking packets belong to different classes with their priority and then treating them differently during forwarding. The main advantage of this approach is its simplicity and scalability, though it is important to point out that prioritized setup does not provide any end-to-end guarantees since it acts on a per hop basis and there is no traffic flow specific bandwidth allocation [4]. This type of QoS provisioning is performed by the UPnP-QoS Prioritized setup.

Prioritized QoS setup in UPnP-QoS works as follows; after the CP requests QoS the QM determines which QoS Devices (QDs) should take part in the forwarding of the traffic flow, by invoking the *GetPathInformation* action, it also verifies the state of these devices via the *GetExtendedQosState* action. Next, the QM obtains the Traffic Importance Number (TIN) for this particular traffic flow from the QPH and attempts the establishment of the QoS on the QDs using the *AdmitTrafficQoS* action, passing the Traffic Descriptor with proper TIN as this action's argument. If no errors occur throughout the above procedure and the configuration of the QDs then the specific traffic flow should be admitted and the QM sends to the CP UpdatedTrafficDescriptor containing up to date information about the traffic specification. The messages exchanged between the UPnP-QoS entities are presented in Fig. 3 above the dashed line.

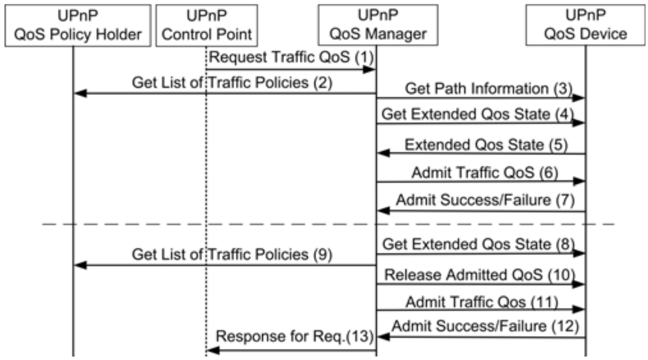

Fig. 3. The UPnP-QoS architecture

As stated before UPnP-QoS does not consider how a QD configures the vertical mapping from TIN to link/network layer prioritization, however the UPnP-QoS specification provides guidelines on how to map the TIN into the VLAN priority tag (802.1Q) and DSCP field, this mapping is presented in Table 1. The TIN, beside the TrafficId (used for unique identification of packets belonging to particular stream), is the only mandatory part of the Traffic Descriptor when setting up prioritized QoS.

Table 1. Vertical mapping between UPnP-QoS TIN and link/network layers

Traffic Importance Number	VLAN / IEEE 802.1Q	DSCP priority
0	0	0x00
1	1	0x08
2	2	0x10
3	3	0x18
4	4	0x20
5	5	0x28
6	6	0x30
7	7	0x38

2.2 Parameterized QoS in UPnP

With Parametrized QoS network resources (typically tokens or forwarding buffer space) are reserved on all involved in traffic forwarding nodes based on a set of parameters such as bandwidth, thus guaranteeing that admitted traffic will be treated in the desired manner. A sequence communication diagram showing the signaling between different UPnP-QoS entities for this setup is as presented in Fig. 3 (both above and below the dashed line - showing the possibility of preemption). As for the prioritized setup the CP initiates the QoS establishment. Next, the QM requests the topology information from QDs, then policies from the QPH and attempts the traffic admittance on the devices on the traffic path.

If the reservation fails the QM can attempt to preempt (if requested) already admitted traffic and re-admit the traffic. Finally, upon successful QoS admittance the QM sends to the CP UpdatedTrafficDescriptor (for parameterized setup containing rate, end-to-end delay, jitter and others values described later in this section).

The key parameters for setting up Parameterized QoS are placed in the Traffic Descriptor structure which is passed as an argument of the *AdmitTrafficQoS* action. This will invoke the admission mechanisms towards the network/link layer. Among many parameters included in the Traffic Descriptor the most relevant for the parameterized QoS setup is the *AvaialbleOrderedTspecList*, which contains a list of Traffic Specifications (Tspec), the Tspec in turn is composed of a number of traffic parameters. Below the Tspec parameters are listed (precisely the v3TrafficSpecification fragment) together with the unit and indication if the field is; o - optional or m - mandatory, for clarity chosen parameters are shortly described.

- RequestedQosType - o - prioritized, parametrized or hybrid
- DataRate - m - bytes per second
- TimeUnit -o- this integer field specifies the smallest time interval in μs
- PeakDataRate -o- bytes per second
- MaxBurstSize -o- bytes
- MinServiceRate -o- bytes per second
- ReservedServiceRate -o- bytes per second
- MaxPacketSize -o- bytes
- E2EMaxDelayHigh -o- desired upper bound of the End-to-End Delay, in microseconds
- E2EMaxJitter -o- microseconds
- E2EMaxDelayLow -o- express that packet delays smaller than E2EMaxDelayLow are not necessary, in microseconds
- QosSegmentSpecificParameters - Interface ID, QoSSegment ID and Segment specific delay and jitter values

3 In Access QoS - GMPLS/RSVP

Generalised MPLS (GMPLS) is a suite of protocols developed by the IETF for reserving resources in networks that may consist of multiple network technologies, for example MPLS, OTN, SDH. The signaling protocol, RSVP-TE, is of interest here as it is responsible for the actual reservations. The GMPLS suite involve other protocols, e.g. OSPF-TE, which is responsible for distributing routing information such as available bandwidth on a particular link (see Fig. 4).

RSVP-TE reserves resources by transmitting a request (the RSVP Path message) from the ingress node through the network to the egress node. The egress node confirms the reservation by replying with a RSVP Resv message which traverses the same path as the request back to the ingress. Any of the network nodes involved in the reservation may upon reception of either message abort the setup by transmitting a PathErr/ResvErr message if e.g. its available resources are less than the requested amount.

A GMPLS network may include other entities separate from the network nodes themselves, such as a Service Management System for initiating the reservation process or a Path Computation Engine that calculates which path is suitable for a particular reservation. Since GMPLS is an extensive effort we will not go into details, more information can be found at the IETF work group CCAMP homepage [5].

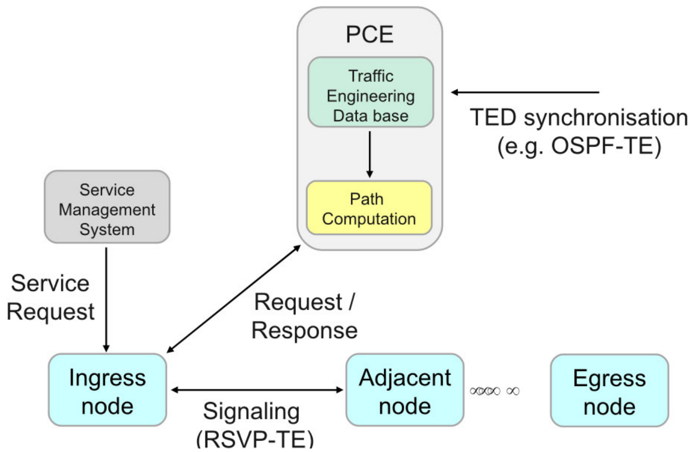

Fig. 4. The GMPLS architecture

3.1 Prioritized QoS in GMPLS

Prioritized QoS in GMPLS network is based on the Differentiated Services (DiffServ) where the Per Hop Behavior (PHB) defines how the flows associated with particular label should be processed in the node, this information is carried in the RSVP-TE DiffServ Object [6]. The RSVP-TE can signal DiffServ in two ways;

- for packet oriented networks E-LSP like approach could be used, where packets or frames can contain priority indication. E-LSP (originally designed for MPLS and named after Experimental (EXP) bits in the Shim header) support multiple Ordered Aggregates (OAs), the priority bits indicate the PHB to be applied to the packet (OAs are the DiffServ Ordered Aggregate, when the traffic belongs to single OA then it is assigned the same Per Hop Behavior Scheduling Class (PSC) and drop precedence),
- for cases where priority is determined by the label (e.g. for cases where there is no possibility of using the priority bits like in λ switching) L-LSPs are used. L-LSP is used to carry the traffic belonging to single OA, supports single PSC that is signaled during the LSP setup procedure (Path message), in this case the priority bits could be used for drop precedence indication.

In GMPLS the Shim header in most cases will not be available and consequently it is impossible to pass traffic requirements using the EXP bit. That is why for later described mapping and further implementations we will consider the L-LSPs. The DiffServ object for the L-LSP is presented on the Fig. 5

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	16 17 18 19 20 21 22 23	24 25 26 27 28 29 30 31
Length = 8	Class-Num 65 (DiffServ)	Class-Type 2(L-LSP)
Reserved	PHBID	

Fig. 5. DiffServ object for the L-LSP

3.2 Parameterized QoS in GMPLS

In the parameterized setup two types of services are distinguished Controlled Load [7] and Guaranteed Services [8]. Control Load should provision QoS in order to give a flow forwarding characteristic that a flow would receive in case of unloaded network. The Controlled Load traffic parameters are listed below:

- Token Bucket Rate (r)
- Token Bucket Size (b)
- Peak Data Rate (p)
- Minimum Policed Unit (m)
- Maximum Packet Size (M)

The Guaranteed Services provide a specific QoS with no packet drop guarantees and delay boundaries, and as such the list of its parameters is extended with the delay information:

- Token Bucket Rate (r)
- Token Bucket Size (b)
- Peak Data Rate (p)
- Minimum Policed Unit (m) - used for overhead calculation
- Maximum Packet Size (M)
- Rate (R) - increases the token bucket rate (r) to reduce queuing delays such that - r=<R=<p
- Slack Term (s) - defines the difference between the desired delay and the delay obtained by using the rate R,

The signaling of the QoS requirements in a GMPLS network is handled during the reservation procedure. The RSVP [9] messages Path and Resv contain objects that pass the information of the traffic flow carried in the LSP to the LSRs on the path. The Path message carries the SenderTSpec object [10] that contains the description of the expected traffic flow. While other objects may change as the message propagates through the network, the Tspec is immutable.

In order to collect the information about the capabilities and resources available on a path the Path message is carrying the Adspec object that is updated by the traversed nodes. Once the Path message reaches the destination it reflects the end-to-end state of the network path. The Adspec object is composed of a default fragment for both Control Load and Guaranteed Services and from service specific fragments. The default Adspec contains number of hops, BW estimate, Minimum path latency, and Composed MTU, if present the Guaranteed Services fragment contains additional values rate-dependent (the C term) and rate-independent (the D term) error factors both end-to-end and from the last traffic shaping point.[1]

The Flowspec object is traversing the network in the reverse direction as part of the Resv message and contains the Receiver TSpec that describes the traffic flow and the Rspec defining the desired service parameters required for service to be invoked.

4 Inter-domain Control and Management Plane QoS Interworking

The studies of the QoS mechanisms and methodologies used in UPnP-QoS and GMPLS show a good match between the UPnP-QoS TrafficDescriptor and RSVP-TE parameters. The following sub-sections will separately treat the mapping for prioritized and parameterized QoS setups.

4.1 Inter-domain Mapping for Prioritized QoS

In the prioritized QoS setup case the mapping can be considered fairly straight forward. The only parameter that is used in the UPnP domain is the TIN which should be mapped into the PHB in the RSVP-TE domain. For the simplest case, eight TINs could be mapped into the eight different values of the EXP bits, defining one-to-one mapping, though as described before that could be done only for a case of a packet oriented network e.g. MPLS where each packet carries the EXP bit in the Shim header.

For a more general case where the TIN matching has to be done with the L-LSP, the LER connected to the home link has to be aware of what is the level of QoS support in particular LSP in order to properly match TIN with PHB. It could be realized by having a number of pre-established LSP matching the number of supported classes and the information about the PHBID assigned to a particular LSP stored in the LER. For cases of dynamic L-LSP establishment the LER needs to ad hoc match the PHBID with the TIN and setup the LSP with proper PHB properties.

[1] The error term C is the rate-dependent error term. It represents the delay a datagram in the flow might experience due to the rate parameters of the flow e.g. serializing delay; the error term D is a rate-independent error term representing the worst case non-rate-based transit time variation per element [8].

The situation becomes more complex when there is a mismatch in a number of classes in the UPnP home and GMPLS - DiffServ access (that can be a case for example when networks are setup at different time using different policies). For such a case there is a need for class merging or splitting. These could be addressed in a couple of ways:

– the traditional approach would be merging basing on the traffic properties; merging all control and management traffic in one group, all real-time traffic classes in the other group, and similarly with all assured forwarding and all best effort flows.
– the mismatch in a number of traffic priorities could be also addressed in other way. Within the scope of the project we are considering remote management of the Home Gateway (HG) using the TR-069 [11]. For such case it would be possible to limit the number of TINs returned by the QPH for flows that will be directed to the access networks, and in this way achieve a one-to-one mapping.

Using TR-069 also addresses, pointed out by [2] the issue of end users responsibility to keep their device's rule sets up to date.

4.2 Inter-domain Mapping for Parameterized QoS Setup

In order to perform mapping for parameterized QoS setup (and we assume here that both home and access networks support this QoS type) the most important task is to match all required RSVP SendersTSPEC parameters with the UPnP Traffic Descriptor. The part of the Traffic Descriptor that contains the information required for parameterized QoS setup and mapping is the v3TrafficSpecification described in Section 2. This UPnP QoS traffic flow specification has to be mapped into the Control Load or Guaranteed Services parameters described in the previous section. Table 2 presents the proposed mapping between the UPnP QoS parameters and GMPLS/RSVP-TE parameters. Explanation for unmapped parameters and clarification of chosen mappings is described below.

The MinServiceRate parameter is defined as the minimal bit-rate that is acceptable as a resource reservation for the requesting application [12], it is not mapped as there is no equivalent parameter in the GMPLS domain. This is not an issue, as the reservation is performed to provision the proper QoS for the service in question and the Data Rate parameter is sufficient for that purpose.

There is no parameter defined in the UPnP-QoS that could indicate the Minimum Policed Unit (m) which indicates the minimum size of the processed packets in order to estimate the worst case overhead for bandwidth calculation [10]. Translation of this information is not mandatory though its lack might cause miscalculation of available bandwidth.

Rate R is the reserved service rate, this is the rate parameter contained in the RSpec (Receivers Specification) and reflects the actual rate that is reserved. This information should also be fed to the CP to update the TrafficDescriptor.

Table 2. Mapping between UPnP-QoS parameters and GMPLS-RSVP

UPnP QoS parameter	GMPLS/RSVP-TE parameter
RequestedQosType	DiffServ/IntServ
Data Rate	Token Bucket Rate (r)
Time Unit	1000000
Peak Data Rate	Peak Data Rate (p)
MaxBurstSize	Token Bucket Size (b)
MinServiceRate	
ReservedServiceRate	Rspec (R) - FLOWSPEC //TODO
MaxPacketSize	Maximum Packet Size (M)
	Minimum Policed Unit (m)
E2EMaxDelayHigh	to be calculated - Ctot, Dtot // TODO
E2EMaxJitter	to be calculated - Min and Max Latency
E2EMaxDelayLow	Minimum Path Latency //TODO
	Slack Term
ServiceType	0 (CL) or 1 (GS)

Slack Term [8] expressed in microseconds is used to indicate the difference between the requested and obtained delay due to the fact that the packets are transmitted with the Rate R from the RSpec instead of Token Bucket rate r.

The delay and jitter parameters could be used for path selection, but this is out of scope for our work at this stage, instead we will focus on communicating the delay and jitter values between access and home networks. The most critical delay related parameter is E2EMaxDelayHigh. As the LSR does not have any knowledge about the committed delay in the home network it cannot be sure that the LSP total delay is low enough to meet the requirement of the requesting application.

In order to save resources we propose a LER behavior where the LSP is released or an error is signaled once the LSP delay is higher than the requested E2EMaxDelayHigh. Additionally, the interface between home and access network should include the possibility of reporting the MaxCommittedDelay parameter (in UPnP-QoS terminology) for the LSP. That will allow the QM to send the E2EMaxCommittedDelayHigh in the UpdatedTrafficDescriptor (being the result of traffic admittance on network devices) to the CP. The UpdatedTrafficDescriptor received by a CP would include delay calculated until the end of the LSP in the access network, which allows the CP to verify if the obtained delay value is within acceptable bounds.

The maximum delay for LSP can be calculated based on the token bucket parameters, C_{tot}, and D_{tot} values according to the formula 1 [10]. The resulting parameter, as described earlier, should be mapped to MaxCommitedDelayHigh and should be reported to the QM.

$$max_{E2Edelay} = b/R + C_{tot}/R + D_{tot} \tag{1}$$

where b is the tocken bucket depth, R is the reserved rate, C_{tot} and D_{tot} are the described earlier error rates.

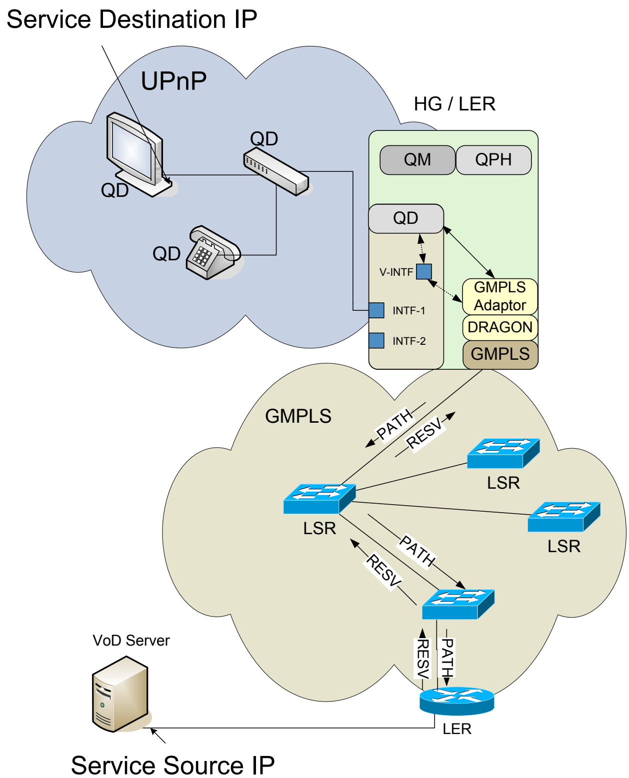

Fig. 6. The UPnP/GMPLS testbed architecture

For reporting MaxCommitedJitter (where MaxJitter is the upper bound on the end-to-end jitter defines as a difference between maximum of End-to-End Delay and the minimum of End-to-End Delay [12]) we propose the maximum LSP jitter to be calculated based on the Minimum Path Latency (part of the default Adspec [10]) assuming that formula 2 holds.

$$\begin{aligned} &MaxCommitedJitter = \\ &\ max(Jitter_1, Jitter_2, ...) \leq \\ &\ b/R + C_{tot}/R + D_{tot} - MinimumPathLatency \end{aligned} \tag{2}$$

where $Jitter_n$ is a jitter value based on a number of consequential packet delay measurements.

This value similarly as for the delay values should be reported to the QM which composes E2EMaxCommitedJitter value to be sent to the CP in the UpdatedTrafficDescriptor.

4.3 Implementation

We have implemented an OSGi-based interface that acts as a proxy between the home and access networks. Upon receiving a traffic description the interface converts the UPnP Traffic Descriptor into parameters expected by the access network testbed. The access network used is based on a number of virtual machines running a modified version of the GMPLS suite DRAGON [13]. It has been tested and proved to successfully interface the different domains. The architecture of the testbed which presentation is out current objective is depicted on Fig. 6.

4.4 Network Security Consideration

When deploying a system that allows an end-user interact with the access network control plane, security is a large concern. We propose to integrate QoS-setup with existing AAA solutions, where users are authenticated and granted access to certain services. The amount of accessible resources could be controlled by the users account type and one could imagine that for example premium subscribers have access to more resources and/or have priority in case of QoS preemption etc.

5 Conclusions and Future Work

This paper presents the proposal for the integration of the UPnP-QoS architecture in home network with GMPLS based access. The parameters required for inter-domain QoS provisioning are outlined and mapping between different domains is presented, while making sure that all relevant information is translated. Additionally, some signaling between domains is presented which allows reporting delay and jitter parameters in order to achieve end-to-end view during traffic setup procedure. The work presented here is a first step towards the test setup where after the development of interface capable of signaling indicated here parameters the integration of the UPnP-QoS architecture with GMPLS test-bed will be presented.

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