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**Information technology – UPnP device architecture –
Part 17-1: Quality of Service Device Control Protocol – Level 3 – Quality of
Service Architecture**

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INFORMATION TECHNOLOGY – UPNP DEVICE ARCHITECTURE –

Part 17-1: Quality of Service Device Control Protocol – Level 3 – Quality of Service Architecture

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This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

¹ UPnP Forum Steering committee, UPnP Forum, 3855 SW 153rd Drive, Beaverton, Oregon 97006 USA. See also "Introduction".

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1 Introduction

This architecture document describes the motivation, use and interaction of the three services that comprise version 3 of the UPnP-QoS Framework:

- The [QosDevice:3](#) Service [QD:3],
- The [QosPolicyHolder:3](#) Service [QPH:3], and
- The [QosManager:3](#) Service [QM:3].

While UPnP-QoS defines three services (listed above), it does not define a new device type. Since Quality of Service issues need to be solved for multiple usage scenarios, it is expected that vendors could use any UPnP device as a container for the services defined by UPnP-QoS.

The UPnP-QoS Framework is compliant with the UPnP Device Architecture version 1.0.

This document is INFORMATIVE. This document is derived from the specifications and it does not describe what is required or optional. For required and optional functionalities, refer to the service definition documents. When there is a conflict between this document and (one of) the service definition documents, the latter prevail. This document avoids the words must, should, and may. Implementers are therefore referred to the appropriate service definition documents for requirements.

Definitions for terms used in this document can be found in [QM:3].

1.1 Versions of the UPnP-QoS Specifications

There are currently three versions of UPnP-QoS.

UPnP-QoS version 1 defines a framework for policy-based prioritized QoS.

UPnP-QoS version 2 extends the version 1 framework with

- A rotameter service to measure network performance and assist in the diagnosis of network problems, and
- A mechanism to indicate a [QosPolicyHolder](#) Service that will be used by the [QosManager](#) Service

UPnP-QoS version 3 extends the version 2 framework with

- Support for Admission Control,
- A mechanism to support a Preferred [QosPolicyHolder](#) Service,
- A way to configure the policy in the [QosPolicyHolder](#) Service.

This document describes UPnP-QoS version 3, please refer to the version 2 [QA:2] or version 1 [QA:1] architecture documents for more information on those versions.

1.2 Informative References

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<http://www.upnp.org/specs/qos/UPnP-qos-QosManager-v2-Service-20061016.pdf> Latest
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[QM:3] – UPnP QosManager:3 Service Document, Available at:
<http://www.upnp.org/specs/qos/UPnP-qos-QosManager-v3-Service-20081130.pdf> Latest
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http://www.upnp.org/standardizeddcp/docs/documents/UPnP_Qos_Device1_000.pdf

[QD:2] – UPnP QosDevice:2 Service Document Available at:
<http://www.upnp.org/specs/qos/UPnP-qos-QosDevice-v2-Service-20061016.pdf> Latest
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<http://www.upnp.org/specs/qos/UPnP-qos-QosDevice-v3-Service-20081130.pdf> Latest
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[QA:1] – UPnP-QoS Architecture version 1.0 Available at: http://www.upnp.org/standardizeddcps/documents/UPnP_QoS_Architecture1.pdf

[QA:2] – UPnP-QoS Architecture version 2.0 Available at: <http://www.upnp.org/specs/qos/UPnP-qos-Architecture-v2-20061016.pdf> Latest version available at: <http://www.upnp.org/specs/qos/UPnP-qos-Architecture-v2.pdf>

2 Architecture Overview

This clause provides an overview of UPnP-QoS v3.

2.1 Scope

The UPnP-QoS specifications are designed with a network in mind that consists of a single IP subnet. Therefore routing between devices in the network is out of scope for UPnP-QoS.

The UPnP-QoS specifications support QoS setup for all traffic streams and UPnP-AV traffic streams in particular. The UPnP-QoS specifications also support QoS management on the LAN for traffic streams originating from or terminating in a WAN.

2.2 Assumptions

UPnP-QoS starts from the basic assumption that a typical UPnP network is heterogeneous in its Admission Mechanisms. Obviously, a homogeneous Admission Mechanism is also accommodated.

2.3 Architecture Summary

This clause is a brief overview of the UPnP-QoS Architecture. In Clause 3 more details are provided on the high-level architecture. Clause 4 describes and illustrates the key concepts. Clause 5 presents the three services in detail and Clause 6 provides details on the interaction between Control Points and the services.

UPnP-QoS defines three services. These are the QosPolicyHolder Service [QPH:3], the QosManager Service [QM:3] and the QosDevice Service [QD:3]. All three services are shown in Figure 1. In this figure, the numbers in parenthesis indicate the order in which the UPnP-QoS actions are invoked.

To illustrate the relationships of various UPnP-QoS components, an example scenario with a simple sequence of setup steps is described below. The detailed operations are described in Clause 6.

Fundamentally, UPnP-QoS manages the QoS for a traffic stream that flows between a source and a sink device. A traffic stream is viewed as a uni-directional flow from a source device to a sink device, possibly passing through intermediate devices.

In the interaction described in this clause, a Control Point application is assumed to have the knowledge of source, sink and content characteristics to be streamed, along with the content's Traffic Specification (TSPEC). The Control Point constructs a TrafficDescriptor structure and requests a QoSManager Service on the UPnP network to setup QoS for a traffic stream (step 1). The Control Point in the QoSManager Service (from hereon referred to as QoS Manager) requests the QoSPolicyHolder Service (step 2) to provide appropriate policy for the traffic stream described by the TrafficDescriptor structure (step 3). Based on this policy, the QoS Manager configures the QoSDevice Service(s) for establishing the QoS for the new traffic stream (step 4).

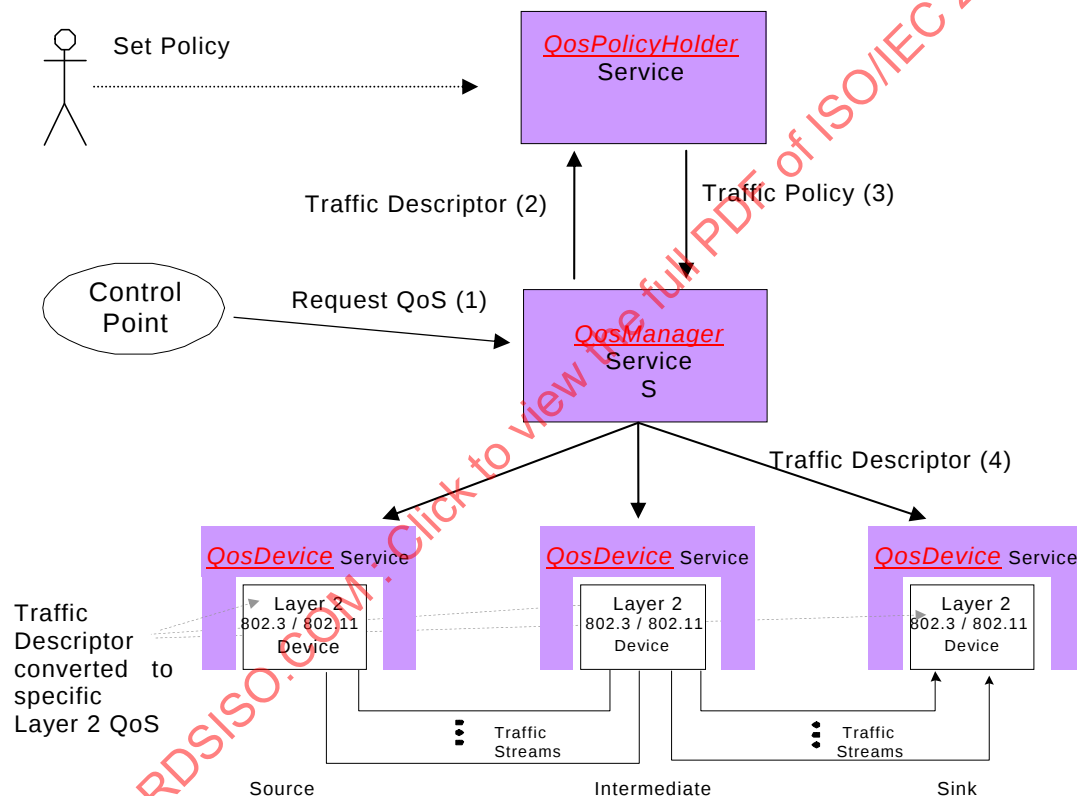


Figure 1 — UPnP-QoS Architecture Overview

The QoSPolicyHolder Service provides traffic policy for the UPnP network on which it resides. It is used to set the importance of a traffic stream by returning a TrafficImportanceNumber and a UserImportanceNumber (these are elements of the TrafficPolicy structure).

For requests for prioritized streams, the TrafficDescriptor structure containing the TrafficImportanceNumber is conveyed to QoSDevice Service(s) by the QoS Manager and is used by the QoSDevice Service to derive the technology specific L2 priority.

The internal mechanism used by the QoSDevice Service for applying the TrafficImportanceNumber is L2 technology specific and is out of scope.

For requests to admit streams, the [TrafficDescriptor](#) structure containing the TSPEC is conveyed to the [QosDevice](#) Service(s) by the QoS Manager and is used by the [QosDevice](#) Service to request admission and possibly a reservation of resources in accordance with the requested TSPEC. If the admission fails because there are insufficient resources, the preferred [QosPolicyHolder](#) Service (see Clause 5.1.4) can be consulted to determine the [UserImportanceNumber](#) for every Blocking UPnP stream. These numbers are used to rank Blocking traffic streams and to determine whether a new traffic stream can be admitted at the expense of existing Blocking traffic streams. The process of taking away resources from existing traffic streams to admit a new traffic streams based on their ranking is called preemption.

3 Architecture

3.1 Policy-based QoS

Policy-based QoS provides a way to assign priority for traffic streams and is also the basis for preemption.

A policy-based QoS system allows an individual or entity to define rules, based on traffic characteristics and to manage the traffic's QoS in the context of the policy system. These rules are then applied to the characteristics of a request to determine the QoS applied. The rules utilize characteristics such as network address or application type.

The [QosPolicyHolder](#) Service provides the mechanism for classifying and ranking traffic streams according to information provided with the action to request QoS for a particular traffic stream. The type of information provided in the [TrafficDescriptor](#) structure includes, among other items, traffic class (best-effort, video, voice, etc.), the source and destination IP addresses for the stream, the TSPEC structure, application name, username, etc. The [QosPolicyHolder](#) Service examines the information provided in the [TrafficDescriptor](#) structure and returns the importance, in the form of a [TrafficPolicy](#) structure.

3.2 Types of QoS

UPnP-QoS supports three types of QoS: Prioritized QoS, Parameterized QoS and Hybrid QoS. Prioritized QoS is the default. Prioritized QoS means end-to-end prioritized QoS. Parameterized QoS requests that network resources are reserved for a traffic stream end-to-end. If there is a non-parameterized QoS technology on the path, then parameterized QoS is not possible end-to-end on the entire path. Hybrid QoS addresses this issue. A request for Hybrid QoS is a request for parameterized QoS on QoS Segments that support parameterized QoS and prioritized QoS on other QoS Segments. If a Hybrid QoS admission fails on a parameterized QoS Segment then Hybrid QoS is not established and an explicit request for Prioritized QoS could be attempted by the Control Point. Note that a request for Hybrid QoS can also fail on a prioritized QoS Segment.

3.2.1 Prioritized QoS

This clause describes the interaction between the services for a request for prioritized QoS. Figure 2 illustrates the interaction. First the Control Point composes a request to the [QosManager](#) Service based, for instance, on the information in the [ContentDirectory](#) Service [CDS:1]. Then the control point invokes the [QM:RequestTrafficQos\(\)](#) action.

The QoS Manager collects information from the various [QosDevice](#) Services in the network. It obtains path information, with the [QD:GetPathInformation\(\)](#) action or other QoS related information with the [QD:GetExtendedQosState\(\)](#) action.

The [TrafficImportanceNumber](#) is determined by the [QosPolicyHolder](#) Service and returned following the [QPH:GetTrafficPolicy\(\)](#) request. Based on the information available in the traffic descriptor (in particular Traffic Class) the [QosPolicyHolder](#) Service provides the

TrafficImportanceNumber. In the case where the QosPolicyHolder Service cannot be used, TrafficImportanceNumber is determined by the QoS Manager using default policies.

The QoS Manager communicates with the QD:SetupTrafficQos() and QD:AdmitTrafficQos() actions to the QosDevice Services with a TrafficDescriptor structure containing a TrafficImportanceNumber consistent with the QoS Policy. The following diagram depicts the sequence of messaging for the setting up QoS for a given traffic stream.

The mapping of the TrafficImportanceNumber to the priority tag value used for the layer-2 network is dependent on the particular L2 technology. The TrafficImportanceNumber has been defined to be consistent with the IEEE 802.1D, Annex G, so it is expected to be a one-to-one mapping from the TrafficImportanceNumber to the priority tag value.

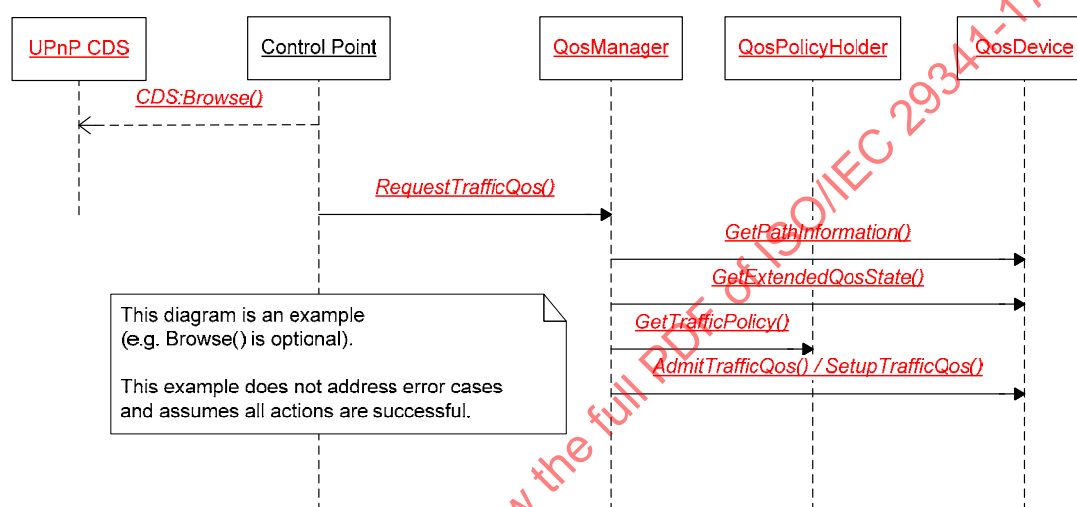


Figure 2 — An Example Interaction Diagram for RequestTrafficQos() action for prioritized QoS setup.

3.2.2 Parameterized QoS

This clause describes the interaction between the services for a request for Parameterized QoS. Figure 3 illustrates the interaction for admission only, whereas Figure 4 includes the interaction for additional QoS Manager capabilities such as preemption and reporting of blocking streams.

In response to a request for Parameterized QoS, the QoS Manager identifies the QosDevice Services on the path. The QoS Manager also identifies the QoS Segments. Further details are provided in Clause 6.

The QoS Manager attempts to admit the traffic descriptor to the QosDevice Services on the path of the traffic stream using the most preferred TSPEC in the list.

In admitting a TrafficDescriptor for a certain TSPEC, the QoS Manager decomposes the end-to-end TSPEC parameters to per-QoS Segment parameters. The QoS Manager subsequently invokes the AdmitTrafficQos() action on the QosDevice Service(s) on each QoS Segment. The QosDevice Service will in turn invoke the appropriate Admission Mechanisms to request resources on the underlying L2 Technology.

If admission fails for the TrafficDescriptor, then the RequestTrafficQos() action fails at any QosDevice, Service. If the QosManager Service supports reporting of blocking traffic streams and/or preemption and if the Control Point has requested the use of these capabilities using the RequestExtendedTrafficQos() action, then: (1) the QoS Manager gathers the information about the blocking traffic streams; (2) the QosManager invokes the preferred

QosPolicyHolder Service to determine the importance order of these existing traffic streams in relation to the new traffic stream; (3) The gathered information is reported to a Control Point.

The Control Point can use this information to inform the user about the state of the network.

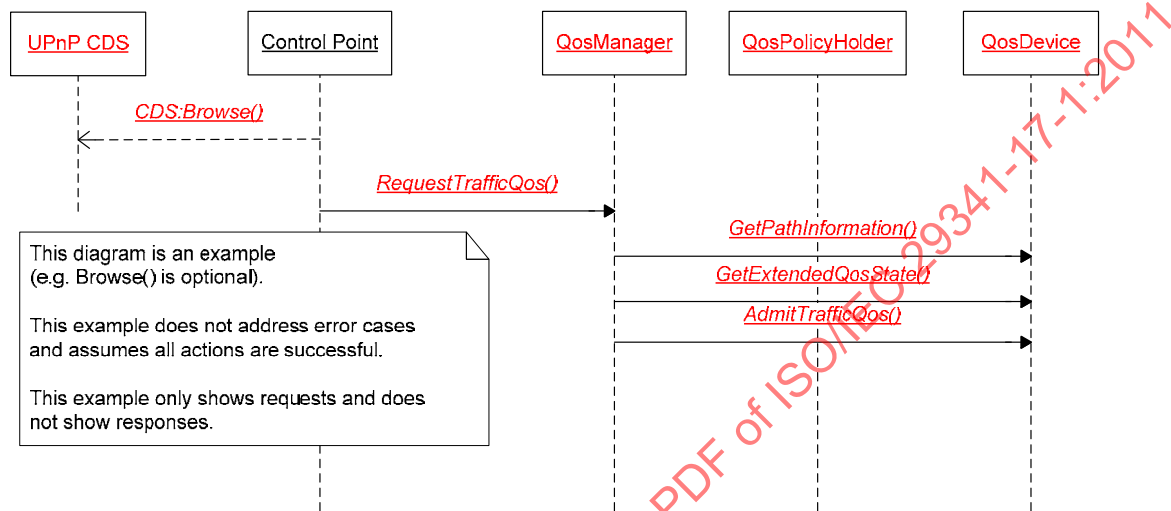


Figure 3 — An Example Interaction Diagram for RequestTrafficQos() (without preemption).

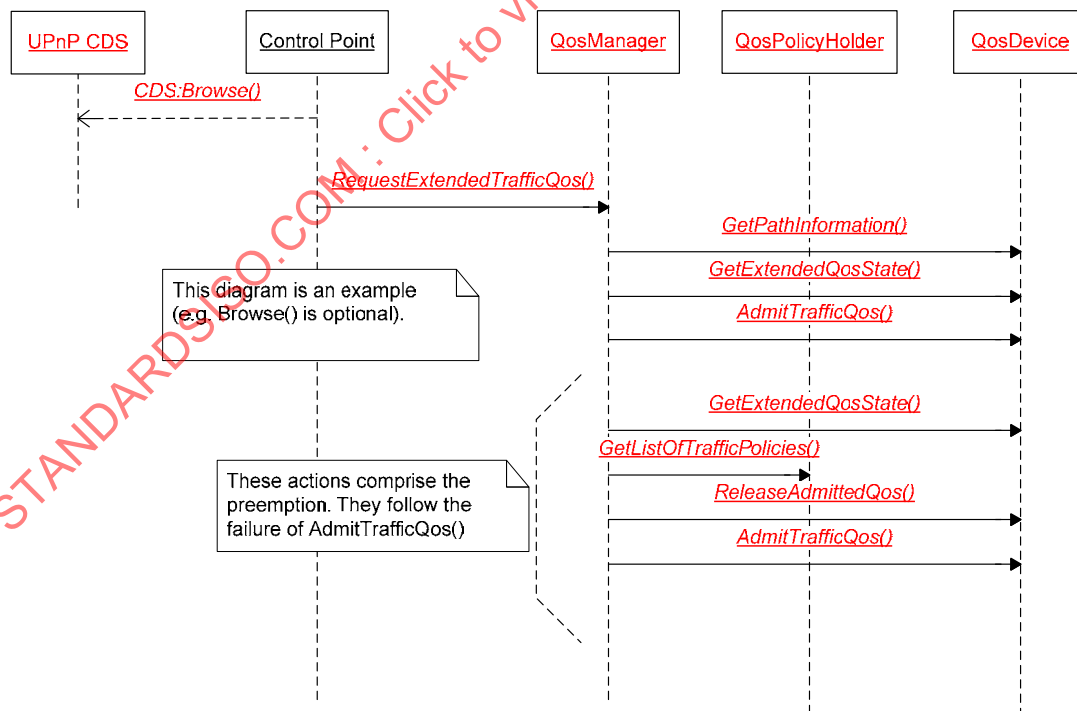


Figure 4: An Example Interaction Diagram for RequestExtendedTrafficQos() with preemption capability.

If preemption is requested, the QoS Manager determines which traffic streams can be preempted to provide sufficient resources for the least preferred TSPEC of the new traffic stream to be admitted on the network. The QoS Manager releases the QoS resources of the traffic streams it determined to preempt and retries admission of the new traffic stream.

Parameterized traffic streams contains a *finite* traffic lease time. The traffic lease time can be updated during the lifetime of the traffic stream. When the traffic lease time has expired, the [QosDevice](#) Service releases the resources. Having a finite traffic lease time ensures that the system can return to a clean state if Control Points or QoS Managers that had set up QoS for certain traffic streams are no longer active.

3.2.3 Hybrid QoS

The setup of Hybrid QoS is similar to the setup of Parameterized QoS.

The difference is that on prioritized QoS Segments, QoS setup is done by the QoS Manager through the [QosDevice](#) Services actions [SetupTrafficQos\(\)](#) or [AdmitTrafficQos\(\)](#) action. The reason is that prioritized QoS Segments can have [QosDevice:1](#) Service [QD:1], [QosDevice:2](#) Service [QD:2], or [QosDevice:3](#) Services [QD:3]. Even if a device implements a [QosDevice:3](#) Service it does not necessarily mean that it supports parameterized QoS.

4 Key Concepts and Examples

This clause provides examples for the key concepts of UPhP-QoS.

4.1 Interfaces and Links

Every [QosDevice](#) Service will have at least one interface which is defined as the point of interconnection between a device and a network. Incoming or outgoing traffic streams use an interface to get from or to the network. Within a [QosDevice](#) Service, Interfaces are identified by their [InterfaceId](#). Example values for [InterfaceId](#) are “eth0” or “Wireless Network Connection”. An interface is of a single technology such as Ethernet.

An interface connects the device to the network and thereby to other devices.

A *link* is an (possibly bidirectional) direct connection between two devices for data exchange. An interface can contain multiple links. In a device, a link can only belong to one interface. Different links can have different properties. For example, in a wireless network the link from the Access Point to one station can have a different signal level and different throughput than the link from the same Access Point to another station. Within an Interface, links are identified through their [LinkId](#).

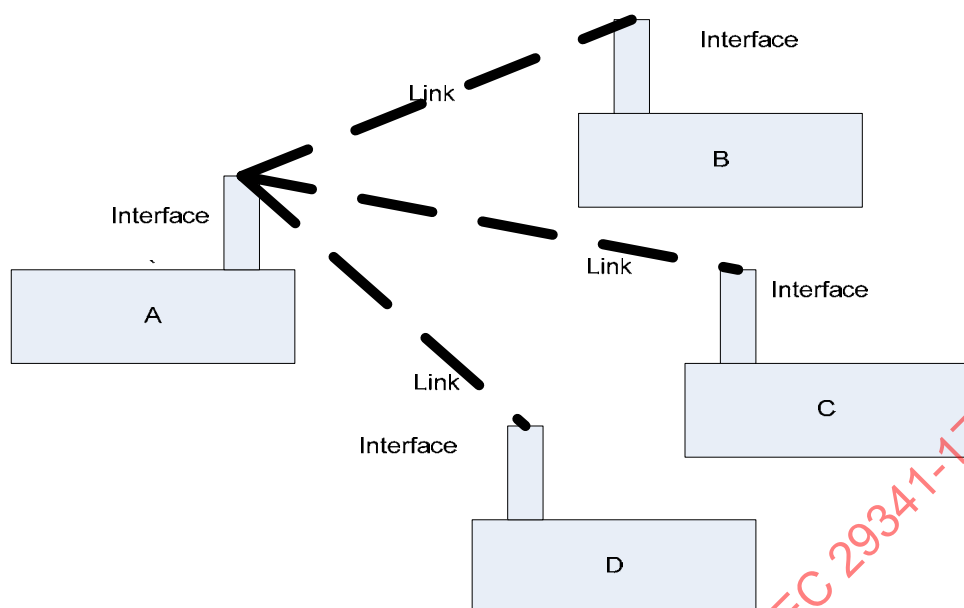


Figure 5 — Example of Interfaces and Links. Device A has 1 interface that contains 3 links. Device B, C, and D each contain an interface with only a single link.

Prior to UPnP-QoS v3, the terms Interface and Link have been used interchangeably. UPnP-QoS v3 defines an interface container as the container for links.

4.2 Path Information

The path, as defined in [QM:3], can be determined on the basis of the path information supplied by the [QoSDevice](#) Service. The path is ordered from source to sink by the sequence of [QoSDevice](#) Services through which it passes.

The [QoSDevice](#) Service reports a [PathInformation](#) structure that contains for each interface, the MAC addresses that have been observed on each of the link(s) that interface contains and whether links are actively bridged within the device.

UPnP-QoS is limited to QoS on a single subnet, therefore the following holds: An intermediate device is on the path if and only if it reports the MAC address of the path's source on a different link than the MAC address of the path's sink and these two links are bridged.

The path from source to sink can now be composed, by the QoS Manager, by sorting all of the devices in the order in which traffic flows starting with the source. This path information can be used to determine adjacency for purposes of invoking an admission request on a [QoSDevice](#) Service.

4.2.1 Example – Bridge on the path

Consider the example in Figure 6. The [QoSDevice](#) Service in this bridge reports that the bridge has one interface containing 4 links: p1, p2, p3, and p4. It reports that the source is on p1 and the sink is on p3. It also reports that p1, p2, and p3 are bridged by the same internal bridge but p4 is not (this is not illustrated in the figure). Since the source and the sink are on different link (p1 and p3 respectively) and the bridge between p1 and p3 is active, this bridge is on the path.

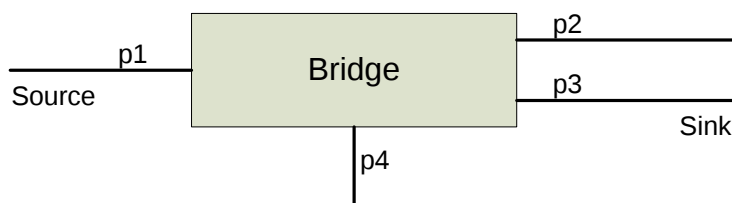


Figure 6 — A bridge is on the path if and only if it reports the MAC address of the source on a different link than the MAC address of the sink and these two links are bridged.

4.2.2 Example – Device not on the path

Consider the example in Figure 7. In this example the laptop is not the source nor the sink of the stream. The *QosDevice* Service in the laptop reports that the laptop has 2 interfaces, each containing a link: p1 (e.g., its wireless interface) and p2 (e.g., its wired interface). It reports that the source is on p1 and the sink is on p2. However, p1 and p2 are not bridged by the laptop. The laptop is therefore not on any path as an intermediate device.

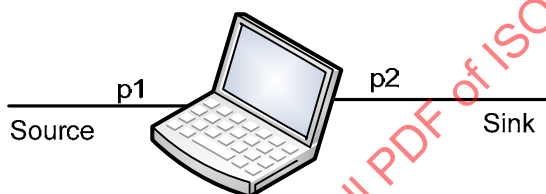


Figure 7 — Laptop is not bridging its interfaces and therefore not on the path

4.2.3 Example – Path Determination

In this example we perform the complete path determination in a larger example: There are three devices (Source, Sink, and Dev 3) and three bridges (Bridge A, Bridge B, and Bridge C) in the network. They are depicted by hashed boxes in Figure 8. Every device also implements the *QosDevice* Service.

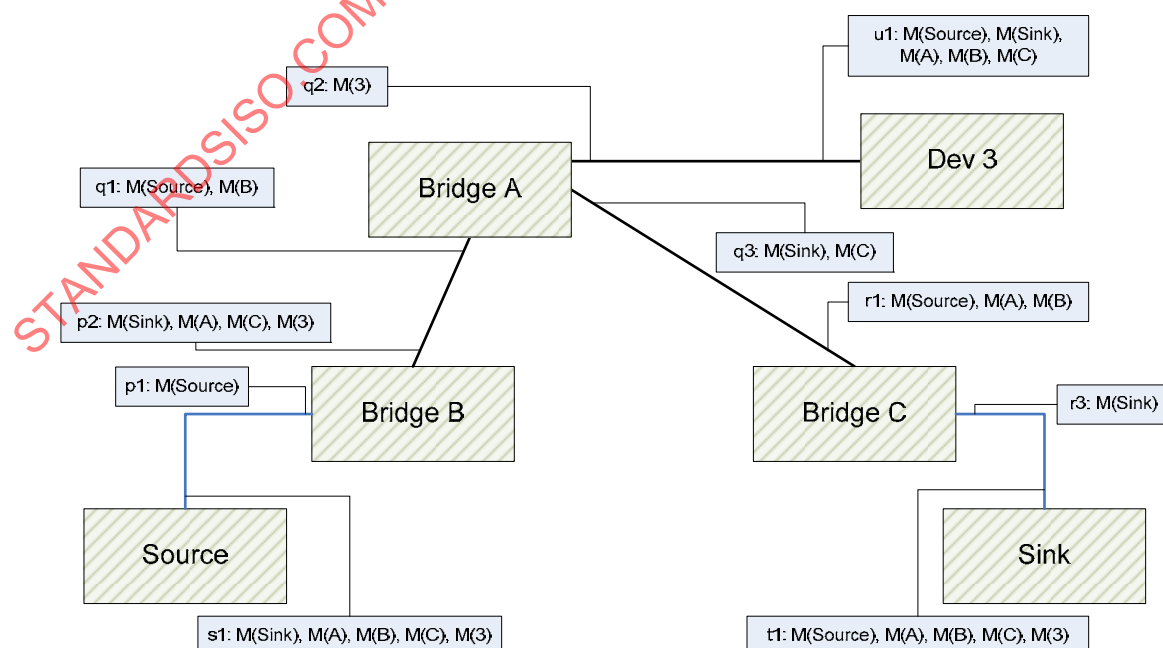


Figure 8 — Example network for path determination

The blue solid boxes indicate what is reported by the QosDevice Service per link in the path information structure. The M(x) refers to the MAC address of x. For example “p1: M(Source)” means that the MAC address of the Source is reported on link p1.

As explained above, the bridges A, B, and C are part of the path from Source to Sink. For bridge A, the involved links are q1 and q3. For bridge B the involved links are p1 and p2. Finally for bridge C, the involved links are r1 and r3.

Note that Bridge A is further downstream than Bridge B (written $B < A$), because for Bridge A, both Bridge B and the Source are on link q1. Also note that $B < C$, this is because for Bridge C, both Bridge B and the Source are on link p1. Finally note that $A < C$, because for Bridge C, both Bridge A and the Source are on link p1. The bridges can now be sorted into $B < A < C$ and the path is: Source – B – A – C – Sink.

In the example every device implements a QosDevice Service and therefore the path could be completely determined because each QosDevice Service is supplying path information. When there are bridges without a QosDevice Service the complete determination of the devices path is not possible from a UPnP-QoS perspective and the QoS Manager will consider just the parts of the path that it has determined.

4.3 QoS Segments

A QoS Segment is the (sub)set of QosDevice Service's interfaces that are under a single Admission Mechanism. The path from a source to a sink is composed of zero (this is the legacy case of non-UPnP-QoS v3 QosDevice Services) or more QoS Segments. When a QosDevice Service has more than one interface and those interfaces are in different QoS Segments, each interface is considered separately for QoS setup. A QoS Segment is needed for an Admission Mechanism that manages resources that are contained on the Segment and not solely on a QosDevice Service. An example is a technology that has a central coordinator that manages the network resources (e.g., transmission opportunities (TXOPs)) for that technology and is only accessible via signaling on that technology segment and not at layer 3 and above. A QoS Segment could contain ingress and egress interfaces when a stream is instantiated on that QoS Segment. The discovery of the path from source to sink produces an ordered list of QosDevice Service's interfaces through which the traffic passes. Each of these QosDevice:3 Services' interfaces identifies the QoS Segment on which it resides. The identifier is called the QosSegmentId. It is unique for each QoS Segment on the network and is identical for all QosDevice Service's interfaces on a given QoS Segment. The QosSegmentId is generated by each QosDevice Service by rules defined in the Technology Addendum.

The QosDevice Services on the path are queried for the QosSegmentId for each of their interfaces. The QosSegmentId is passed to a QosDevice Service when admission, update, or release is performed for a QoS Segment. The recipient QosDevice Service uses the QosSegmentId for purposes of managing Segment resources, in addition to managing any resources local to the QosDevice Service (e.g, buffers).

The following clauses provide examples of QoS Segments.

4.3.1 Example – Simple QoS Segment

In Figure 9 a simple network consisting of four power line devices is drawn. The network contains three devices that contain the QosDevice Service and a fourth infrastructure device that does not contain a UPnP service and is indicated by the term “CCo”.

According to the QosSegmentId formation rules (see [QDA:3]), the three QosDevice Services independently report the same QosSegmentId. It can therefore be concluded that the three devices are in the same QoS Segment. The “CCo” is also in that QoS Segment. However if there is no QosDevice Service on the “CCo”-device, this “CCo” cannot be managed directly by UPnP-QoS and its existence is therefore (at the UPnP-QoS level) irrelevant.

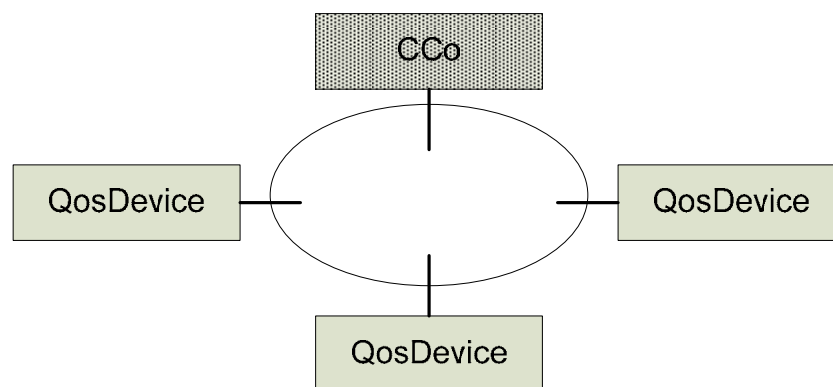


Figure 9 — A simple network with one QoS Segment

4.3.2 Example – Multiple QoS Segments

In Figure 10 the network is extended with an additional Wi-Fi network. The QosDevice C reports two QosSegmentIds, one starting with 174 on one interface and one starting with 071 on the other interface. QosDevice D reports the same QosSegmentId (starting with 071). This network contains two QoS Segments. When a stream traverses both QoS Segments, both QoS Segments will require QoS setup via the QosDevice Services on the Segments. Thus QosDevice C will be setup for QoS twice, once for each interface. For example, suppose that QosDevice A is the source and QosDevice D is the sink. The path is: A then C (first the interface on the 174-Segment, then the interface on the 071 Segment) and then D

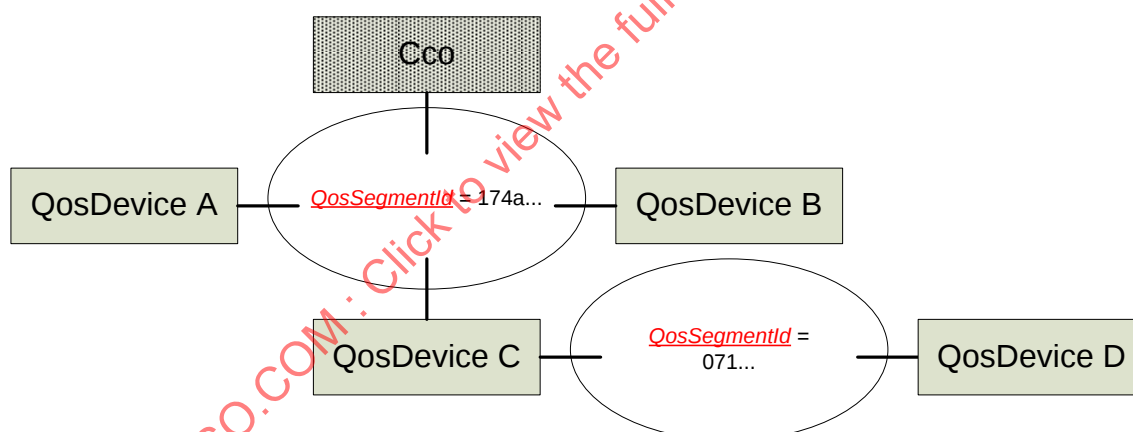


Figure 10 — A network with two different technologies and two QoS Segments

4.3.3 Example – Homogeneous QoS Segment with L2 QoS Bridges

Another network is shown in Figure 11. This network consists of five devices and three bridges. The bridges are special bridges in that they also bridge L2 QoS setup requests; such a bridge is called, in this example, an L2Q bridge (for Layer-2-QoS Bridge). Every interface of every device is wired Ethernet. In the architecture, no distinction of links within the interface is made. For ease of explanation, we assume all devices implement the QosDevice Service.

Devices A, B, and C are end points in a QoS Segment bridged by an L2Q bridge and report the same QosSegmentId. Bridge 2 has four interfaces, two in the QoS Segment bridged by an L2Q bridge and a third and a fourth interface in the “006” Segment. Device D reports a QosSegmentId starting with “006” for Ethernet. Device D is therefore in another QoS Segment. Because Device D also connects to Bridge 2, the interface from Bridge 2 reports a QosSegmentId starting with “006” and the interface of Bridge 2 to Device D is not part of the L2Q QoS Segment with QosSegmentId “L2Q000000”.

Bridge 3 and Device E are attached to the “006” Segment. Therefore Bridge 3 and Device E will report a QosSegmentId starting with “006” for Ethernet.

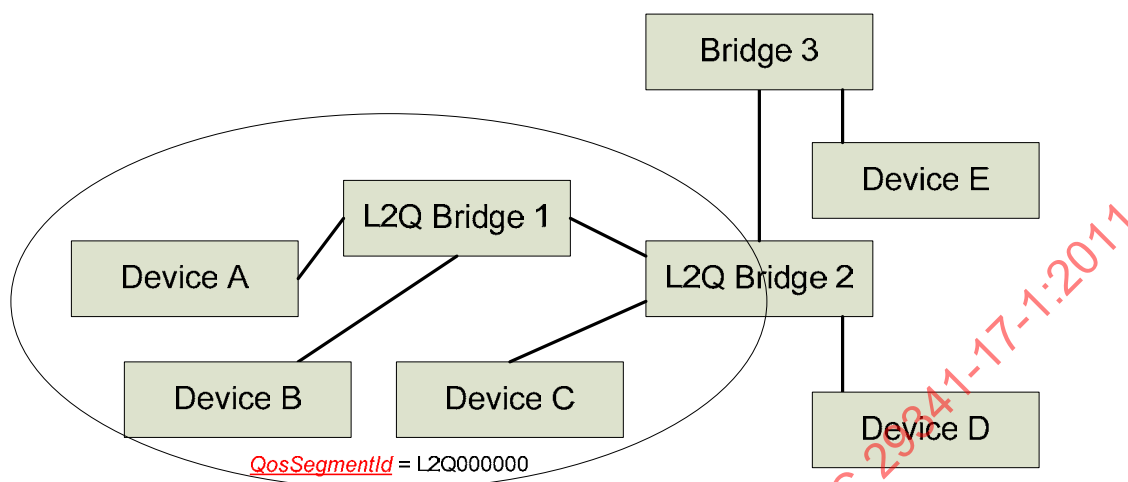


Figure 11 — A network with Ethernet Layer-2-QoS bridges, L2Q-end point devices and legacy Ethernet bridges and legacy Ethernet devices

4.3.4 Example – Heterogeneous QoS Segment with L2 QoS Bridges

The fourth example is a network where different L2 technologies are bridged through Layer-2-QoS bridges. An example is shown in Figure 12, where L2Q-end point devices over Ethernet are bridged to L2Q-end point devices over MoCA. For ease of explanation, we assume all devices implement the QosDevice Service.

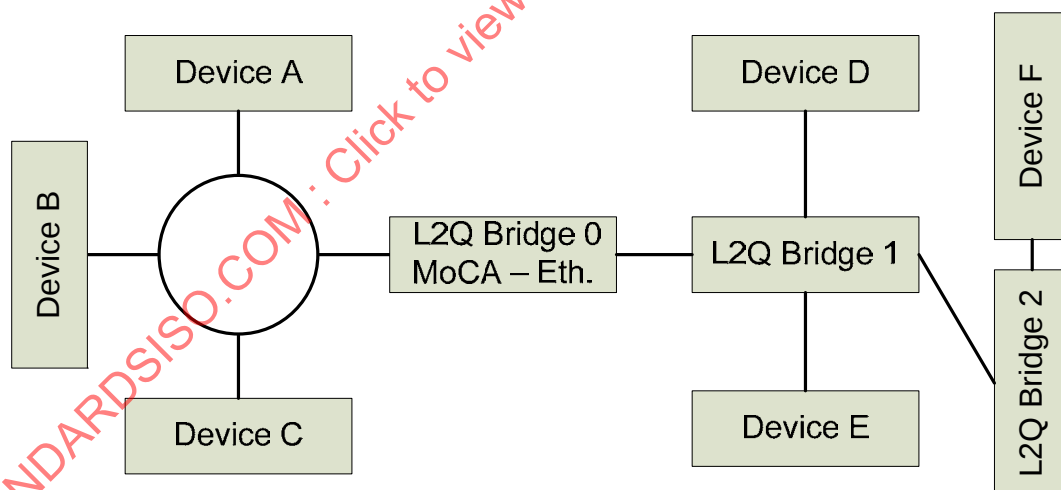


Figure 12 — A network with all L2Q-end point devices but with different underlying technologies: MoCA (left hand side) and Ethernet (Right hand side), respectively

The L2Q Bridge 0 between MoCA and Ethernet (in the middle of the figure) bridges both traffic and L2Q QoS setup. A QosDevice Service implemented on the L2Q Bridge 0 (not shown) exposes the same QosSegmentId on both interfaces and hence does not divide the two sides into two QoS Segments. Therefore, the entire network in the figure will be treated as a single QoS Segment.

It is now demonstrated that all devices indeed are part of the same QoS Segment. On the left hand side, devices A, B, and C are connected via MoCA to a shared medium. The device A, B, and C are end point devices in a QoS Segment bridged by an L2Q bridge and report the

same QosSegmentId. The devices D, E, and F are also devices in a QoS Segment bridged by L2Q Bridge 1 and L2Q Bridge 2 that have the same QosSegmentId.

4.3.5 QosSegmentId generation examples

The QosDevice Service Addendum [QDA:3] lays out the rules for creating a QosSegmentId for the technologies that were considered at the time of creating the UPnP-QoS specifications. The QosSegmentId is the same for interfaces that are connected to each other within the same QoS Segment but differs for interfaces in another QoS Segment, even if the interfaces use the same Layer 2 technology.

For Layer 2 technologies not described in the Addendum the following conditions are considered:

- Every QosDevice Service implementation on top of the Layer 2 technology has to generate a string.
- This string has to be identical for all interfaces of all QosDevice Service instances within the same QoS Segment.
- This string has to be unique to identify the QoS Segment from other QoS Segments in the same network.

There is no supporting technology provided by UPnP-QoS to do this. The QosSegmentId typically starts with 3 digits to indicate the IANA technology type and it is followed by a technology specific string. Typical examples are by using a network name, a string representation of a MAC address of the scheduler, the outcome of a Layer 2 leader election.

4.4 Adjacency of QosDevice Services

The concept of QoS Segment is introduced to hide the Layer 2 dependencies of QoS setup on the Segment, from the QoS Manager. A typical QoS Segment is illustrated in Figure 13 where on both the ingress as well as the egress end of the QoS Segment a QosDevice Service is located. The subject that is addressed in this clause is: which service is responsible for performing (which part of) the Layer 2 QoS setup. The Layer 2 protocols define the capabilities of the devices.

If, for example, the Layer 2 technology for this QoS Segment requires the sink and not the source within the QoS Segment to setup QoS, then QosDevice Service B is able and needs to perform the Layer 2 request for a traffic stream that flows from A to B. Similarly the QosDevice Service A is able and needs to perform the Layer 2 request for a traffic stream that flows from B to A. For other Layer 2 technologies, it could be the source but not the sink that has to setup QoS, either the source or the sink that sets up QoS, or the source and the sink together that have to setup QoS.

The adjacency determination is performed by the QoS Manager and used to signal a QosDevice Service that there are adjacent QosDevice Services within the Segment. A QosDevice Service can use the adjacency information to avoid the situation where two QosDevice Services would accidentally reserve the resource twice, without requiring QosDevice Service to search for other QosDevice Services and without making a QoS Manager dependent on the specifics of Layer 2 technologies.

The QoS Manager supplies an input parameter to the QosDevice Service that contains two Boolean variables. The first Boolean variable QDUpstream indicates whether there exists another QosDevice Service further Upstream for the stream *within* the same QoS Segment. The second Boolean variable QDDownstream indicates whether there exists another QosDevice Service further Downstream for the stream *within* the same QoS Segment. The invoked QosDevice Service can make a determination, based on the Admission Mechanism that it implements, of the correct action for resource management; the QosDevice Addendum provides details for specific Admission Mechanisms.

Consider a traffic stream that enters the QoS Segment at A and leaves the QoS Segment again at B as in Figure 13. The QosDevice Service A is informed that there exists a QosDevice Service further downstream but not further upstream. Also QosDevice Service B is informed that there exists a QosDevice Service further upstream but not further downstream. If the Layer 2 requires the sink in the QoS Segment to setup QoS, then QosDevice Service B is responsible for performing the Layer 2 request for a traffic stream that flows from A to B and therefore requested to do so. In this case QosDevice Service A does not perform any action.

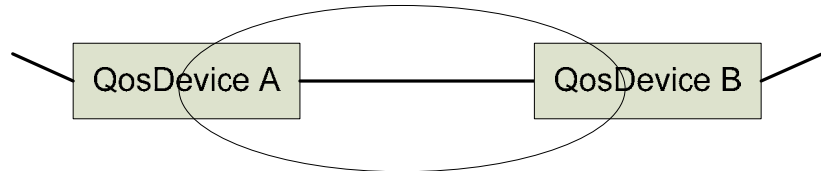


Figure 13 — QoS Segment with two QosDevice services

Now consider the situation of Figure 14, where the sink in the Segment does not implement a QosDevice Service. In this case, the QosDevice Service A is informed that it has neither downstream nor upstream neighbors within the same QoS Segment. If the Layer 2 requires the sink in the Segment to setup QoS and does not allow the source to do so, then no QoS for the traffic stream from A to B can be requested. However, if the Layer 2 merely prefers the sink in the Segment to setup QoS, but allows the sources to also do so, the QosDevice Service A will perform the setup because there is no other capable device.

The [QDA:3] document describes the requirements for certain technologies. They could be helpful to the reader as examples in understanding the general theory.

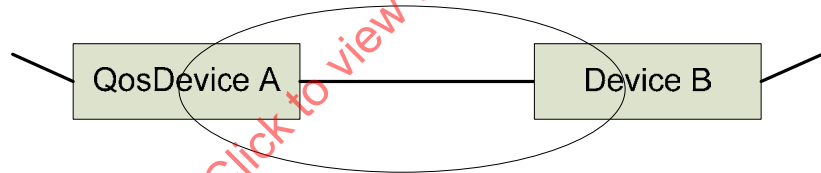


Figure 14 — QoS Segment with only one QosDevice Service

The rules for the QoS Segment that are applied by the QosDevice Service for Admission Mechanism invocation are summarized in Table 4-1. For example if the Admission Mechanism for which the QosDevice Service needs to setup QoS requires the sink to setup QoS, the initiating QosDevice Service is the most downstream QosDevice Service. This QosDevice Service invokes resource management because it is the only QosDevice Service that receives "QDDownstream = 0".

Table 4-1 — Overview of the Admission Mechanism invocation

Adm.Mech. Initiation	Initiating <u>QosDevice</u> Service	Characterization
Only by the sink	Most downstream <u>QosDevice</u> Service	<u>QDDownstream</u> = 0
Only by the source	Most upstream <u>QosDevice</u> Service	<u>QDUpstream</u> = 0
By source OR sink	Most downstream <u>QosDevice</u> Service	<u>QDDownstream</u> = 0
By source AND sink	Most upstream <u>QosDevice</u> Service	<u>QDUpstream</u> = 0
	Most downstream <u>QosDevice</u> Service	<u>QDDownstream</u> = 0.

See [QDA:3] for how the rules apply to certain Layer 2 technologies.

5 UPnP-QoS Services

UPnP-QoS defines three UPnP services. The services are the [QoSPolicyHolder](#) Service, the [QoSManager](#) Service and the [QoSDevice](#) Service. This clause provides an overview of these three services, respectively.

5.1 The [QoSPolicyHolder](#) Service

5.1.1 Overview

The UPnP [QoSPolicyHolder](#) Service is a repository of QoS policies for the UPnP network. These QoS policies can be configured by the user or a third party on behalf of the user to indicate the treatment of traffic on the UPnP-QoS network. The [QoSPolicyHolder](#) Service provides a UPnP-defined interface for a QoS Manager to access the network QoS policies. The policy within the [QoSPolicyHolder](#) Service can be populated through a UPnP-QoS defined configuration mechanism (see Clause 5.1.6).

The main function of this service in a prioritized network is to judiciously allocate the use of traffic importance numbers by traffic streams so that traffic importance levels are not overused. In a prioritized system the traffic importance number is mapped into a priority and if a given priority were overused, it would essentially lose differentiation.

The other role of the [QoSPolicyHolder](#) Service is to provide information to differentiate various traffic streams on the network by their importance for the purposes of Preemption.

The [QoSPolicyHolder](#) Service also provides additional information to identify the source of the QoS policy.

In UPnP-QoS v3 a mechanism is introduced for the user to prefer a [QoSPolicyHolder](#) Service. The [QoSPolicyHolder](#) Service also plays a role in maintaining this preference over time while devices are turned on or off.

5.1.2 Traffic Stream QoS Policy Description

The QoS traffic policy consists of elements specific to QoS and elements to identify the source of the QoS policy.

The QoS specific elements are

- [AdmissionPolicy](#) (a string),
- [TrafficImportanceNumber](#) (an integer in the range of 0-7), and
- [UserImportanceNumber](#) (an integer in the range of 0-255).

The elements of the QoS policy that identify the source of the QoS policy were introduced in UPnP-QoS version 2. These are

- [PolicyHolderId](#) (a string containing UDN and ServiceId),
- [PolicyLastModified](#) (a string with a date),
- [PolicyModifyingUserName](#) (a string), and
- [PolicyHolderConfigUrl](#) (a string with a URL).

The value of the [AdmissionPolicy](#) string is ignored for the version 3 [QoSPolicyHolder](#) Service and its value is always “enabled”. A version 3 QoS Manager requests admission control for parameterized QoS on the applicable [QoSDevice:3](#) Services.

The value [TrafficImportanceNumber](#) indicates a traffic stream's priority. The [QoSDevice](#) Service maps [TrafficImportanceNumber](#) to a Layer 2 priority as per the Addendum [QDA:3].

The value UserImportanceNumber is used by the QoS Manager as the basis for admission policy decisions when the network resources are saturated. The UserImportanceNumber value is used by the QoS Manager in admitting new traffic streams by preempting the QoS for existing traffic streams so that traffic streams with higher UserImportanceNumber values are accommodated first. A value of 255 indicates the highest importance and a value of 0 indicates lowest importance.

The PolicyLastModified string indicates with a date value when the policy was last modified, while the PolicyModifyingUserName string identifies the user or other entity that modified the policy for the last time. The PolicyHolderConfigUrl string contains a URL that points to the policy configuration page of the device.

5.1.3 Multiple instances of the QosPolicyHolder Services

The QosPolicyHolder Service provides an interface to supply the QoS policy for a given traffic stream, described by the TrafficDescriptor.

In UPnP-QoS version 1, the assumption was that there is exactly one QosPolicyHolder Service in the network.

In UPnP-QoS version 2, the existence of multiple instances of the QosPolicyHolder Service is allowed. The Control Point could indicate a QosPolicyHolder Service of its choice to the QosManager Service.

In UPnP-QoS version 3, the user has the ability to prefer a QosPolicyHolder Service. From then on every QoS Manager uses that Preferred QosPolicyHolder Service to determine traffic policy for requests for hybrid or parameterized QoS. For Prioritized QoS, the behavior of UPnP-QoS version 2 is maintained.

The behavior of the QoS Manager in the presence of different versions of the QosPolicyHolder Service is described in 6.3. The requirements can be found in the [QM:3].

5.1.4 Preferred QosPolicyHolder Service

In UPnP-QoS version 3, the user has the ability to prefer a QosPolicyHolder Service. From then on every QoS Manager uses that Preferred QosPolicyHolder Service to determine policy for requests for hybrid or parameterized QoS.

In order to select a preferred QosPolicyHolder Service, a control point invokes the QPH:SetAsPreferred() action with SelectAsPreferred = 1 parameter on the QosPolicyHolder Service it wants to make the preferred QosPolicyHolder Service. The QosPolicyHolder Service will then ensure that this preference is maintained in the network even when some devices are turned on or off. Any control point can also revoke the earlier preference of a QosPolicyHolder Service by invoking the QPH:SetAsPreferred() action with SelectAsPreferred = 0 parameter on any active QosPolicyHolder Service (i.e., not necessarily the Preferred QosPolicyHolder Service) in the network.

A non-preferred QosPolicyHolder Service will still respond to UPnP requests for QoS policy.

5.1.5 Maintaining the Preference of a QosPolicyHolder Service

This clause describes how to maintain the preference of a QosPolicyHolder Service in a network where devices tend to come and go.

When a QosPolicyHolder Service is selected as preferred with the QPH:SetAsPreferred() action or when a Preferred QosPolicyHolder Service is rebooted then it performs the Preferred QosPolicyHolder Service propagation mechanism which is described below.

In this propagation mechanism process, the QosPolicyHolder searches for instances of the QosDevice Service on the network and invokes the QD:SetPreferredQph() action on each of them. This action needs to be invoked only once per advertised QosDevice Service. The QosDevice Service stores this information persistently across reboots. As soon as the action fails on a QosDevice Service with “Invalid Preferred QosPolicyHolder service” error, the QosPolicyHolder Service completes the propagation mechanism process and knows that it is no longer the Preferred QosPolicyHolder Service. If the QD:SetPreferredQph() action fails on a QosDevice Service for reasons other than those stated above then the QosPolicyHolder Service is still considered preferred.

5.1.6 Configuring the QosPolicyHolder Service

The policy in the QosPolicyHolder Service can be configured through a set of UPnP actions. The underlying model is that an ordered list of policy rules are maintained and used while responding to GetTrafficPolicy() and GetListOfTrafficPolicies() actions. To determine the policy, the QosPolicyHolder Service evaluates the list in order until there is a match.

The AddQphPolicy() action allows to insert a rule in a certain position in the table. The rule provides the filter conditions, the TrafficImportanceNumber and ImportanceNumber. The ImportanceNumber is a static priority that is used by the QosPolicyHolder Service to derive a relative UserImportanceNumber (see [QPH:3]).

The evented state variable PolicyVersion enables tracking the changes to the policy database. This allows a Control Point to detect asynchronous changes to the policy database.

5.2 The QosManager Service

The QosManager Service defines a set of actions for a Control Point to setup, release, and update the Quality of Service for a traffic stream. The QosManager Service performs those activities over the entire path of the traffic stream by making use of the QosDevice Services in the network. To control those QosDevice Services, a UPnP Control Point is needed. The behavior of this Control Point is driven by the actions invoked on the QosManager Service. This Control Point is called QoS Manager even if there is no exposed QosManager Service.

5.2.1 Overview

The QoS Manager is responsible for managing QoS assigned to various traffic streams. To fulfill its role, the QoS Manager acting as a Control Point discovers and invokes actions advertised by QosDevice Services and the QosPolicyHolder Services on the network.

The main function of the QosManager Service in a prioritized network is to request, for a traffic stream, the TrafficImportanceNumber value from the appropriate QosPolicyHolder service on the network. Based on the TrafficImportanceNumber returned from the QosPolicyHolder service, the QoS Manager configures the relevant QosDevice Services to assign the appropriate priority to the traffic stream.

In a network with admission control, the role of the QoS Manager is to admit a traffic stream to the network on the basis of the traffic stream's requirements from the traffic specification (TSPEC). The Control Point can supply a list of TSPECs with which the traffic stream can operate so that if one TSPEC cannot be admitted another can be attempted. For example two TSPECs can be provided for certain TV content: one for High Definition, and one for Standard Definition.

If admission fails, the QoS Manager performs preemption provided the preemption feature is implemented by the QosManager Service, requested by the Control Point and allowed by the QosPolicyHolder Service.

5.2.2 Behavior

When a QoS Manager completes setting up QoS for a traffic stream, all [QosDevice](#) Service(s) in the network path will have stored the traffic descriptor (more details are provided in the [QosDevice](#) Service clause). Any QoS Manager can query the [QosDevice](#) Service(s) and determine the state of a traffic stream. This enables a [QosManager](#) Service to operate without maintaining any state.

Some [QosManager](#) Services implement the [RequestExtendedTrafficQos\(\)](#) and [UpdateExtendedTrafficQos\(\)](#) actions which support additional capabilities such as reporting of blocking streams and preemption. A Control Point can determine whether a [QosManager](#) Service implements the features “reporting of blocking streams” and “preemption”, by invoking the [QM:GetQmCapabilities\(\)](#) action.

A Control Point invokes the [QM:RequestTrafficQos\(\)](#) or [QM:RequestExtendedTrafficQos\(\)](#) actions to setup QoS by providing (among other things) a [TrafficDescriptor](#).

The Control Point uses the [RequestedQosType](#) parameter to indicate that the Control Point wants to request parameterized QoS, or hybrid QoS (parameterized where available, prioritized where parameterized is not supported). If the [RequestedQosType](#) parameter is omitted, then prioritized QoS is requested.

The Control Point can also request that the [QosManager](#) Service reports which traffic streams are blocking admission or ask for preemption of the less important traffic streams in the case of failure to admit the requested traffic stream.

If a Control Point indicates a [QosPolicyHolder](#) Service of its choice and requests for prioritized QoS, then the [QosManager](#) Service will retrieve the [TrafficImportanceNumber](#) from the indicated [QosPolicyHolder](#) Service.

For requests for parameterized QoS, the QoS Manager determines the network path, the QoS Segments and will admit the traffic stream at all appropriate [QosDevice](#) Services.

The [QosManager](#) Service provides an interface (the [RequestTrafficQos\(\)](#) and [RequestExtendedTrafficQos\(\)](#) actions) for a Control Point to request QoS for a traffic stream identified by a [TrafficDescriptor](#). The [QosManager](#) Service will return the [TrafficDescriptor](#) (in addition to other parameters) which will contain additional information such as the TSPEC that is currently active. If the [QosManager](#) Service is not successful, then it returns a corresponding error code.

Lastly, the [QosManager](#) Service provides an action for removing the QoS for a traffic stream.

5.2.3 Update the QoS reservation

The [QosManager](#) Service supports actions to update QoS of existing streams. If the update fails because the resources are not available, then the [QosManager](#) Service maintains the stream's current reservation.

In general, but specifically for update, it is the Control Point's responsibility to ensure that resources are requested before they are used and resources are no longer used before released. This is especially relevant when using Layer 2 Technologies that do not police actual resource usage.

5.3 The [QosDevice](#) Service

5.3.1 Overview

The [QosDevice](#) Service is implemented in a source, sink or intermediate network device. A QosDevice Service is responsible for managing the resources in the device. The [QosDevice](#)

Service can also be responsible for managing and reporting the resources for other devices in the same QoS Segment.

5.3.2 Behavior

The QosDevice Service provides an interface for Control Points to execute actions on the device to admit traffic streams to setup QoS, to query the QoS capabilities and state of the QosDevice Service, to remove a traffic stream's QoS, and to register for events that the QosDevice Service generates. Typically, a QoS Manager acts as a Control Point for QosDevice Service. The QosDevice Service has an interface to configure and report per interface rotameter observations.

A QosDevice Service exposes its QoS capabilities through the GetExtendedQosState() action. This action supersedes the v1-defined GetQosDeviceCapabalities(), GetQosState(), and GetQosDeviceInfo() actions.

The GetExtendedQosState() action exposes QoS capabilities such as the type of Native QoS support, the maximum PHY bandwidth, IANA technology type, MAC address, InterfaceId and AdmitCntrlNet.

The run time QoS state is reported by returning a list of TrafficDescriptor structures for every traffic stream admitted or registered on the QosDevice Service..

The AdmitTrafficQos(), ReleaseAdmittedQos() and UpdateAdmittedQos() actions provide the core functionality to request admission, to release resources and to update the resource requests respectively. The AdmitTrafficQos() action sets up QoS. If RequestedQosType = 0 or absent, then Prioritized QoS is requested and a traffic stream is always admitted. For parameterized QoS Segments and RequestedQosType = 1 or 2, the QosDevice Service is requested to reserve the requested resource for the indicated TSPEC of the provided TrafficDescriptor. If this admission succeeds, the QosDevice Service reports success. If the resource cannot be reserved, then the request will fail. If a QoS Manager wants to establish prioritized QoS on QoS Segments where the admission fails, it therefore has to explicitly request Prioritized QoS.

The UpdateAdmittedQos() action can be used to request a change in reservation for an existing admitted traffic stream. The UpdateAdmittedQos() action has the following two properties:

- If the UpdateAdmittedQos() action fails, the current reservation will be maintained.
- If the UpdateAdmittedQos() action requests fewer resources than the original reservation (for example, decreasing the bandwidth requirement or increasing the maximum end-to-end delay requirement) then the request will be successful.

These two properties of the QosDevice Service allow a QoS manager to ensure that either an update requested by the Control Point succeeds or the current reservation is maintained in case of failure (see also Clause 5.2.3 and Clause 6.5.9).

For backward compatibility with version 1 and 2, the SetupTrafficQos() and ReleaseTrafficQos() actions are maintained. Their behavior is available through the AdmitTrafficQos() and ReleaseAdmittedQos() actions as well. The SetupTrafficQos() action of the QosDevice Service allows the QoS Manager to setup QoS associated with a particular traffic stream. The ReleaseTrafficQos() action of the QosDevice Service allows the QoS Manager to release QoS associated with a particular traffic stream.

The topology information known to the QosDevice Service is exposed via the GetPathInformation() action. The GetQosDeviceInfo() and GetExtendedQosState() actions allows the QosDevice Service to expose the IP addresses, port numbers and IP protocol of a particular traffic stream.

A QosDevice Service can collect information about network flows (rotameter) from its interfaces.

If a Control Point is interested in querying these rotameter observations, it first configures the service using the ConfigureRotameterObservation() action, then subsequently (e.g. a user initiated diagnostic session) request one or more observations using the GetRotameterInformation() action. The rotameter service has to be configured well before observations are requested (otherwise there could be insufficient data to provide diagnostic value).

The rotameter report contains counters that report the total traffic count for each device attached to a given interface or separate counters for each implemented priority queue. For parameterized QoS, ROBitsParameterized and ROPacketsParameterized provide the number of bits and packets related to parameterized QoS streams. There are also a number of parameters that are specific per traffic stream. These are the StreamBitsTransmitted, StreamPacketsTransmitted, StreamPacketsReceived, and StreamPacketsDropped.

These counters are useful for diagnostic purposes, i.e. ascertaining which device(s) on the network are most active (sending or receiving the most data), and therefore likely candidates for causing congestion. Because no distinction is made between bits sent or received in each counter, other UPnP-QoS methods are used to ascertain the source (versus the sink) of traffic (this can be done by simply querying the QosDevice for active TrafficDescriptor instances).

5.3.3 Configuring QoS

When the QosDevice Service action AdmitTrafficQos() or SetupTrafficQos() is invoked, the request is for a specific TSPEC. The QosDevice Service only attempts that TSPEC. The selection of different TSPECs is up to the QoS Manager. The QosDevice Service also does not perform preemption itself. If requested by the Control Point, preemption is performed by the QosManager Service (provided it supports that feature). The QoS Manager uses the ReleaseAdmittedQos() and/or UpdateAdmittedQos() action. .

5.3.4 Path Information

The QosDevice Service has an action that provides information regarding the devices in the network that are reachable through each of its active interfaces. This information is for a QosManager Service to correctly detect the topology, adjacency and the QoS Segments.

When there is a change in PathInformation, the QosDevice Service issues an event and sends the updated PathInformation variable in the body of the event.

5.3.5 Ancillary actions

In this clause we describe four actions in the QosDevice Service that support the operations of the QoS system. The SetL2Map() action provides a QosDevice Service with a mapping from a TrafficHandle to a Layer2StreamId. With this mapping devices can filter on Layer2StreamId which is generally simpler than filtering on TrafficId.

The VerifyTrafficHandle() action is provided as a mechanism to verify whether a specific TrafficHandle is still valid on the QosDevice Service without searching in the complete list as returned by the GetExtendedQosState() action.

The UpdateTrafficLeaseTime() action allows to update only the traffic lease time of a TrafficDescriptor without doing a full UpdateAdmittedQos() action.

The SetPreferredQph() action supports the selection of a preferred QosPolicyHolder Service.

5.3.6 Events

The QosDevice Service can implement two evented state variables to keep track of the registered and admitted traffic streams: MostRecentStreamAction and UnexpectedStreamChange. The MostRecentStreamAction state variable contains counters that track whether the SetupTrafficQos() and ReleaseTrafficQos() actions are successfully invoked. The UnexpectedStreamChange state variable is a counter which is incremented after unexpected stream changes which could either be because unexpected things happen at the L2 Technology or when a traffic stream's resources are otherwise removed. Both these events are moderated to avoid flooding the network with repeated events. After receiving the event that indicates a change for UnexpectedStreamChange, a subscribed QoS Manager or other Control Point invokes the GetUnexpectedStreamChanges() action to obtain more information on what has happened.

6 System Operation

An overview of the operational flow of UPnP-QoS control messages is given below, more detailed information is provided in the related subclauses.

- a) Initiation of the QoS setup for a traffic stream – The QosManager Service requires a minimum set² of information from a Control Point to perform the QoS setup. The method used to gather this information for different usage environments is described in Clauses 6.1 and 6.2.
- b) Determination of Policy for the traffic stream – The QoS Manager determines the appropriate policy by requesting this information from the QosPolicyHolder Service. In some situations, the QoS manager will have to apply default policy.
- c) Determination of QosDevice Services that have to be managed – Based on the source and destination information for the traffic stream the QoS Manager determines which QosDevice Services play a role in the transport of the traffic stream.
- d) Configuration of QosDevice Service – the QoS Manager will interact with each applicable QosDevice Service to setup QoS for the traffic stream on the device. The device's setup will depend on the capabilities of the device and could include setting of packet handling priorities, other setup functions, allocation of resources, as well as Admission Mechanism signaling to request admission.
- e) Return the results of the QoS setup to the Control Point invoking the QosManager Service – the success or failure of setup is provided to allow user feedback or other possible corrective actions.

6.1 Selection of a QosManager Service

The Control Point firsts select a QosManager Service. To find all QosManager Services, a Control Point performs an M-SEARCH for a QosManager Service embedded in any UPnP device type.

Control Points that do not select a QosManager Service, implement or provide a QoS Manager. There are zero or more QosManager Services in the network. These are known through standard UPnP discovery methods. The method for selection of a QosManager:1 Service [QM:1] or a QosManager:2 Service [QM:2] is not defined in the UPnP-QoS specification.

The selection of the QosManager:3 Service typically depends on the capabilities of the QosManager Service. The QM:GetQmCapabilities() action is used to obtain the capabilities of the QosManager Service. The following capabilities are currently defined:

- The QosManager Service can perform admission on a First-Come-First-Served basis.

² see the TrafficDescriptor Matrix in QosManager Service document [QM:3] for examples

- The QosManager Service can, if capable, preempt existing traffic streams if their UserImportanceNumber is smaller than that of the new traffic stream to make room for the new traffic stream.
- The QosManager Service can report a list of existing blocking traffic streams so that the Control Point could perform some QoS management itself.

Every QosManager:3 Service is capable of performing admission on a First-Come-First-Served basis.

6.2 Invoking the QosManager Service

When a QosManager Service is selected, its QoS setup operation is triggered either through the QM:RequestTrafficQos() action or through the QM:RequestExtendedTrafficQos() action. The QM:RequestExtendedTrafficQos() action was introduced in QosManager:3 Service. The behavior of the QM:RequestTrafficQos() action is a subset of the QM:RequestExtendedTrafficQos() action.

It is recommended that Control Points that need to setup parameterized QoS for multiple traffic streams, invoke the QM:RequestTrafficQos() and/or QM:RequestExtendedTrafficQos() action serially. This reduces unnecessary competition for reservations. QosManager Services could also defer execution of the QM:RequestTrafficQos() and/or QM:RequestExtendedTrafficQos() action when they are still working on the completion of an earlier invocation.

The control point provides a TrafficDescriptor structure to the QosManager Service. This structure contains both the TrafficId which determines for which traffic stream QoS is requested and the TSPEC(s) that specifies resource requirements for the traffic stream. The RequestedQosType parameter is used to specify which type of QoS is requested (prioritized QoS, parameterized QoS, or hybrid QoS) as defined in Clause 3.2.

The information provided in the TrafficDescriptor by the Control Point to the QosManager Service and the related process steps are described in the subclauses. A generic process for any Control Point is described in Clause 6.2.5. However, since streaming in UPnP AV is out-of-band in the specific case of an independent AV Control Point such a requester of QoS could not know all details of the specific traffic stream for which QoS is requested. The UPnP-QoS services add specific support to deal with this case by allowing an AV Control Point to supply an incomplete TrafficId and providing means for the QosManager Service to complete the TrafficId. This is described in Clause 6.2.6.

6.2.1 Initiation of QoS Setup (I)

The QM:RequestTrafficQos() action sets up QoS. This provides the QosManager Service with a (partially complete) TrafficDescriptor. Upon completion of the QM:RequestTrafficQos() action, the QosManager Service returns the TrafficHandle, NumPolicyHolders and UpdatedTrafficDescriptor to the Control Point.

- The TrafficHandle is a unique identifier associated with that TrafficDescriptor to be used in all future interactions.
- The NumPolicyHolders value indicates the number of QosPolicyHolder Services that are available in the network if neither a preferred QosPolicyHolder Service exists nor a QosPolicyHolder Service was selected by the CP. A value other than “1” indicates that the default policies have been used by the QosManager Service. A value of “1” indicates that the policy provided by the preferred QosPolicyHolder Service or the Control Point selected QosPolicyHolder Service has been used or that exactly one QosPolicyHolder Service was found on the network.

6.2.2 Initiation QoS Setup (II)

The QM:RequestExtendedTrafficQos() action can also be used to setup QoS. Similar as with the QM:RequestTrafficQos() action, this provides the QosManager Service with a (partially

complete) TrafficDescriptor. In addition to this, the SelectedQmCapabilities argument contains the options governing QoS setup. This contains the following information,

- The control point allows the QosManager Service to preempt (Preemption=1) or forbids the QosManager Service to preempt existing traffic streams (Preemption=0).
- The QosManager Service returns a list of blocking traffic streams if its admission was not successful (ReportBlockingStreams=1).

Upon completion of the QM:RequestExtendedTrafficQos() action, the QosManager Service returns the TrafficHandle, (an updated) UpdatedTrafficDescriptor, an integer ResultedQosType, and the ExtendedTrafficQosInfo including a (possibly empty) list of Blocking Traffic Streams to the Control Point.

- The TrafficHandle is a unique identifier associated with that TrafficDescriptor to be used in all future interactions.
- The returned UpdatedTrafficDescriptor is the one that was completed by the QosManager Service and was used in the setup of QoS.
- The ResultedQosType argument describes the result of the admission. It for example reports whether the end-to-end path passes through prioritized QoS Segments.
- The ListOfBlockingStreams in ExtendedTrafficQosInfo is populated when the QosManager Service was unable to admit the new traffic stream and the Control Point had requested a list of blocking streams.

The behavior of the QM:RequestTrafficQos() action is the subset of the QM:RequestExtendedTrafficQos() action with Preemption=0 and ReportBlockingStreams=0.

6.2.3 Release of QoS Resources

The QM:ReleaseTrafficQos() action requests the QosManager Service to release QoS for the traffic stream that corresponds to the provided TrafficHandle. It is recommended that a QosManager Service process this invocation as soon as possible, as there could be ongoing QoS setup activities that benefit from the released resources.

6.2.4 Changing the QoS Setup

The QM:UpdateTrafficQos() and QM:UpdateExtendedTrafficQos() actions request a change in QoS. The behavior of the QM:UpdateTrafficQos() action is a subset of the QM:UpdateExtendedTrafficQos() action just like the behavior of the QM:RequestTrafficQos() action is a subset of the QM:RequestExtendedTrafficQos() action. The high-level properties of the update are that

- Even if the QM:UpdateTrafficQos() or QM:UpdateExtendedTrafficQos() action fails, the reservation is maintained.
- If the requested update results in a request of fewer resources, the QM:UpdateTrafficQos() or QM:UpdateExtendedTrafficQos() action succeeds.

6.2.5 Integrated Control Point

In the case of an integrated Control Point (a Control Point that is located in an endpoint), the UPnP-QoS architecture assumes Control Point will manage the binding between the traffic stream and the TrafficDescriptor. This means that the invocation of the QosManager Service is done by a Control Point that has knowledge of the setup of the transport method. The control point has to provide the QosManager Service with the complete TrafficId information and the TSPEC.

The integrated Control Point is present in the following applications:

- UPnP AV services, two box model: In the two box model there is a MediaServer device (MSD) and a Media Server Control Point. The device that hosts the Media Server Control

Point (MSCP) is the initiator of the QoS setup. The MSCP will locate content on the MSD, retrieve its URI and start playback. The initiation of QoS Setup can be done after the establishment of an AV session for the traffic stream but before the content transfer starts.

- Generic case (not UPnP AV services): Any application is able to initiate QoS setup as long as it can provide the information needed by the [QosManager](#) Service.

6.2.6 Independent AV Control Point

This AV Control Point case refers to the situation where there is an AV Control Point that is not necessarily co-resident with the Media Render device (MRD) or the Media Server device (MSD). The AV Control Point contains a Media Server Control Point and a Media Renderer Control Point. This is referred to typically as the three box model. For further information refer to the UPnP AV architecture [AV].

In the three box model case, the AV Control Point initiating the [RequestTrafficQos\(\)](#) action on the [QosManager](#) Service could be unaware of the complete [TrafficId](#). The AV Control Point knows the UDN of the [MediaServer](#) device (typically the source) and the [MediaRenderer](#) device (the destination). The AV control point includes these addresses in its request.

The [QosManager](#) Service uses the [QD:GetQosDeviceInfo\(\)](#) or [QD:GetExtendedQosState\(\)](#) actions on the [QosDevice](#) Service instances in the [MediaServer](#) and the [MediaRenderer](#) device to query for the [TrafficId](#).

The [QosDevice](#) Service in the [MediaServer](#) device returns the [SourceAddress](#) it will use for the traffic stream. This address could be different from the address the MediaServer uses for its UPnP communications. The [QosDevice](#) Service in the [MediaServer](#) also reports the port numbers and the [IpProtocol](#). The destination reports the information from its side.

The UDN of the [MediaServer](#) and of the [MediaRenderer](#) device are typically not sufficient to uniquely identify the traffic stream in the [QosDevice](#) Services. Therefore the AV Control Point needs to include other AV specific information to help the [QosDevice](#) in the [MediaServer](#) and [MediaRenderer](#) devices to relate the QoS request to the AV requests. The items that can be provided are

- [MediaServerConnectionId](#) – this is the [ConnectionId](#) as provided by the [ConnectionManager](#) Service of the [MediaServer](#) device.
- [MediaRendererConnectionId](#) – this is the [ConnectionId](#) as provided by the [ConnectionManager](#) Service of the [MediaRenderer](#) device.
- [AVTransportInstanceId](#) – this is the [InstanceId](#) of the [AVTransport](#) Service on the [MediaServer](#) or [MediaRenderer](#) that is responsible for the AV transport of this traffic stream.
- [AVTransportUri](#) – this is the URI of the content which originates in the [ContentDirectory](#) Service.

To facilitate the identification by the [QosDevice](#) Service as many of the above parameters as possible have to be supplied.

6.2.7 Determination of QosBoundary Source and Destination

The QosManager will setup QoS on the network bounded by the [QosBoundarySourceAddress](#) / [QosBoundarySourceUuid](#) and [QosBoundaryDestinationAddress](#) / [QosBoundaryDestinationUuid](#)

If the Control Point provides the [QosBoundarySourceUuid](#) and not the [QosBoundarySourceAddress](#), then the IP Address needs to be determined. It can be obtained from the [QosDevice](#) Service at the UPnP device with the provided UUID (likely a gateway).

If neither Address nor UUID format are provided, the QoSManager assumes it manages the subnet on which it itself is located and determines the [QosBoundarySourceAddress](#) and [QosBoundaryDestinationAddress](#) if necessary.

6.2.8 Creation of the TSPEC (Traffic Specification)

The Control Point is responsible for providing the TSPEC (Traffic Specification) to the [QosManager](#) Service. These TSPEC parameters define the desired performance characteristics. The generation of the TSPEC parameters is left to the Control Point.

Parameters specific to content exposed via the AV [ContentDirectory:2](#) Service could have an associated [res@tspec](#) property.

6.3 Determination of Policy for the Traffic Stream

The QoS Manager communicates with the [QosPolicyHolder](#) Service to obtain the [TrafficPolicy](#). In this clause we describe how the QoS Manager determines the [QosPolicyHolder](#) Service that it needs to use.

6.3.1 Preferred [QosPolicyHolder](#) Service

In UPnP-QoS 3, the user can initially determine which [QosPolicyHolder](#) Service the user prefers and sets this preference through the [QPH:SetAsPreferred\(\)](#) action. This [QosPolicyHolder](#) Service is called the Preferred [QosPolicyHolder](#) Service.

The [QosDevice](#) Services store this preference in persistent memory. The QoS Manager invokes the [QD:SetPreferredQph\(\)](#) action to retrieve the [PreferredQphId](#) containing the [UDN](#) and [serviceld](#) of the [QosPolicyHolder](#) Service most recently set as preferred by the user and the [QphPreferenceCount](#) which quantifies this “recentness” of the user’s selection. The QoS Manager now determines which [QphPreferenceCount](#) is the largest of all those reported by [QosDevice](#) Services on the network and uses the [PreferredQphId](#) associated to that number. If there are 2 (or more) [QosDevice](#) Services with the same [QphPreferenceCount](#) number but a different [PreferredQPHId](#) then there was a synchronization error. This error can occur in the rare case that two (or more) users simultaneously selected a new [QosPolicyHolder](#) Service and this error lasts until one user successfully reselects a [QosPolicyHolder](#) Service.

If the [PreferredQphId](#) value is “NULL”, then the user did not prefer any [QosPolicyHolder](#) Service.

When the [QosPolicyHolder](#) Service associated with the [PreferredQphId](#) is not available or there are two [QosDevice](#) Services reporting a different [PreferredQphId](#) for the same largest [QphPreferenceCount](#), the QoS Manager applies default policy (see Clause 6.3.7).

6.3.2 CP-Indicated [QosPolicyHolder](#) Service

Since UPnP-QoS v2, the Control Point can indicate a [QosPolicyHolder](#) Service which is the [QosPolicyHolder](#) Service that has to be used. If a Control Point indicates a [QosPolicyHolder](#) Service, but that [QosPolicyHolder](#) Service is not currently available on the network, an error occurs and the Control Point’s request for QoS fails.

6.3.3 Single [QosPolicyHolder](#) Service

In UPnP-QoS v1, if there is exactly one [QosPolicyHolder](#) Service on the network, that policy will be applied. If there are more [QosPolicyHolder](#) Services on the network or there is no [QosPolicyHolder](#) Service on the network the default policy is applied. The default policy is described in Clause 6.3.7.

6.3.4 Priority Order of QosPolicyHolder Services for Prioritized QoS

For requests for Prioritized QoS, the following ordering is applied by the QoS Manager

- a) CP-indicated QosPolicyHolder Service
- b) Preferred QosPolicyHolder Service (if CP did not indicate QosPolicyHolder Service)
- c) Single available QosPolicyHolder Service (if CP did not indicate QosPolicyHolder Service and Preferred QosPolicyHolder Service = "NULL")

If none of the above applies, default policy is used.

6.3.5 Priority Order of QosPolicyHolder Services for Parameterized QoS and Hybrid QoS

For requests for Hybrid QoS or Parameterized QoS, the following ordering is applied by the QoS Manager

- a) Preferred QosPolicyHolder Service
- b) CP-indicated QosPolicyHolder Service (if Preferred QosPolicyHolder Service = "NULL")
- c) Single available QosPolicyHolder Service (if CP did not indicate QosPolicyHolder Service and Preferred QosPolicyHolder Service = "NULL")

If none of the above applies, default policy is used.

6.3.6 The QosPolicyHolder Service

The QoS Manager uses the GetTrafficPolicy() or GetListOfTrafficPolicies() actions of the QosPolicyHolder Service to retrieve the policy for the traffic stream defined by the information in the TrafficDescriptor. The QosPolicyHolder Service will provide the following information:

- AdmissionPolicy for prioritized QoS is compatible with UPnP-QoS versions 1 and 2. For all streams with RequestedQosType > 0, the AdmissionPolicy is ignored.
- TrafficImportanceNumber this parameter is used to determine the packet priority value (for prioritized and hybrid QoS requests) for the traffic stream. The QoS Manager provides it to the QosDevice Services, to allow priority tagging of the packets.
- UserImportanceNumber provides a relative ranking of the traffic stream's user importance compared to that of the other traffic streams. These numbers are used in the context of preemption (see Clause 6.6)
- PolicyHolderId is a value that uniquely identifies a network device implementing the QosPolicyHolder Service.
- PolicyLastModified is a string that identifies the date/time when the policy on a device with the QosPolicyHolder Service was last modified.
- PolicyModifyingUserName is a string that identifies the user who last changed the policy
- PolicyHolderConfigUrl is a string containing the URL on the device that provides the QosPolicyHolder Service.

6.3.7 Default Policy

This paragraph describes the default policy...

The TrafficImportanceNumber default is based on the TrafficClass. This default mapping of Traffic Class to TrafficImportanceNumber is defined in the QosManager Service document.

The default UserImportanceNumber is 0, the lowest importance. The use of the same number for every traffic stream leads to First-Come-First-Served admission control.

6.4 Determination of QosDevice Services that have to be managed

To setup QoS for the traffic stream, the QoS Manager determines the devices that are directly involved in the transport of the traffic stream and the type of QoS setup that is requested. The Control Points (including QosManager and QosPolicyHolder) discover QosDevice Services embedded in any UPnP device type as it is expected that QosDevice Services can be added to any UPnP device (MediaServer, MediaRenderer, InternetGateway, Basic, etc.).

6.4.1 Configuration of QoS Devices

The configuration of the QosDevice Services is controlled by the QoS Manager. Depending on the particular requirements of the traffic stream and capabilities of the QosDevice Services on the path of the traffic stream, the QoS Manager determines the setup as described in the following clauses.

6.4.1.1 Priority Setup Strategy

For prioritized QoS, configuring the traffic stream source device with the appropriate packet priority (TrafficImportanceNumber) is typically sufficient for setup of QoS. Upon successful completion of QD:SetupTrafficQos(), a source device implementing the QosDevice Service prioritizes the traffic associated with the TrafficId, according to the TrafficImportanceNumber on its output interface.

Intermediate devices are also configured with the traffic stream's TrafficDescriptor. Intermediate devices implementing the QosDevice Service with PacketTaggingSupported = "Yes" reprioritize the traffic associated with the TrafficId according to the TrafficImportanceNumber on their output interfaces irrespective of the priority on the incoming packets.

6.4.2 Path Determination

The QoS Manager uses the TrafficId information together with the response from QD:GetPathInformation() received from each QosDevice Service to determine which devices are on the path as described in Clause 4.2. The information returned by QD:GetPathInformation() action can also be used to determine the applicable network interfaces.

The QoS Manager first determines the source and sink QosDevice Services by comparing the source and sink IP address in the TrafficId to the IP addresses of all discovered QosDevice Services available on the network.

The QoS Manager then identifies which other QosDevice Services are on the path with the help of the information returned by the QD:GetPathInformation() action (see the examples in Clauses 4.2.1 and 4.2.2). An intermediate device is on the path if and only if it reports the MAC address of the source on a different interface than the MAC address of the sink and these two interfaces are bridged.

Finally the QoS Manager sorts the QosDevice Services based on the fact that for every QosDevice Service A and QosDevice Service B, QosDevice Service B is farther from the source than QosDevice Service A ($A < B$), if B reports that A and the source are on the same interface (see the example in Clause 4.2.3).

6.4.3 QoS Segment Identification

When a traffic stream has to be setup, the QoS Manager determines the QoS Segments through which the traffic stream traverses.

The QoS Manager identifies QoS Segments by querying every [QosDevice](#) Service on the network via [QD:GetExtendedQosState\(\)](#) action and comparing the [QosSegmentId](#)s of the different Interfaces. This process provides the QoS Manager with a list of all QoS Segments.

6.5 Admission Control

This clause describes the Admission Control in further detail. In this clause the procedure is completed by decomposing end-to-end requirements into per-QoS Segment requirements and setting up QoS on a Segment.

6.5.1 Decomposition of End-to-End Requirements into Per-QoS Segment Requirements

The QoS Manager sets up QoS on a per-QoS Segment basis but it needs to meet end-to-end requirements. This means that the QoS Manager needs to decompose the end-to-end requirements into per-QoS Segment requirements for some parameters. Other parameters apply globally.

Not every traffic stream has specific requirements on end-to-end delay, jitter or loss because the application can work with any finite delay, jitter or loss as long as these values are known to the application. The [QosManager](#) Service has to return the values for achieved upper bounds on end-to-end delays, jitter and loss.

As an example, suppose the Control Point has specified [E2EMaxDelayHigh](#) = 100 and there are two QoS Segments A and B. The QoS Manager could request a [QosSegmentMaxDelayHigh](#) = 50 at each QoS Segment. If both requests succeed, the requirement that [E2EMaxDelayHigh](#) = 100 is obviously met. The [QosDevice](#) Service returns the achieved [MaxCommittedDelay](#) and the [QosManager](#) Service returns the sum of the individual [MaxCommittedDelay](#) values to the Control Point as the achieved [E2EMaxDelayHigh](#).

Another method is that, the QoS Manager does not include a specific per-QoS Segment requirement in its interaction with the [QosDevice](#) Service. The [QosDevice](#) Service minimizes delay when reserving resources for the traffic stream with the given TSPEC characteristics and to return the achieved value. The result could be that QoS Segment A achieves [MaxCommittedDelay](#) = 30 and QoS Segment B achieves [MaxCommittedDelay](#) = 60. The sum of these is clearly less than 100 and hence the requirement is met. Without further information a [QosDevice](#) Service provides the least [QosSegmentMaxDelayHigh](#) for its QoS Segment which could lead to an unnecessary burden on the resources.

A third method the QoS Manager can follow is to first investigate what the [QosDevice](#) Service can likely deliver. For this the QoS Manager invokes the [QD:GetExtendedQosState\(\)](#) action which has the [TrafficDescriptor](#) structure as a input argument. From the returned [ProtoTspec](#) structure the QoS Manager can derive which maximum values for the [QosSegmentMaxDelayHigh](#) parameters would have worked if an admission was made at the time the [QD:GetExtendedQosState\(\)](#) action was invoked. There is no guarantee that these values will work because the network state could have changed.

For some L2 technologies determining a [ProtoTspec](#) structure is straightforward because the values can be derived from the operating mode the L2 technology is in, the specific implementation or even the standard. But the determination of a [ProtoTspec](#) structure could for other L2 technologies amount to performing an admission and releasing any resources. A [QosDevice](#) Service on those latter L2 technologies will likely not return a useful [ProtoTspec](#) structure.

To support the decomposition of [E2EMaxDelayHigh](#) the parameter [E2EMaxDelayLow](#) can be used by the [QosManager](#) Service. The [E2EMaxDelayLow](#) parameter, if supplied by a Control Point, means that actual [E2EMaxDelayHigh](#) values below [E2EMaxDelayLow](#) are not needed. This is useful for Admission Mechanisms that would otherwise reserve with the smallest delay possible. For example, if the Control Point specifies [E2EMaxDelayHigh](#) = 1000 and

E2EMaxDelayLow = 700, then this means that the QosManager Service has to achieve an E2EMaxDelayHigh of at most 1000 but it also means that it is not necessary to achieve an E2EMaxDelayHigh below 700. If the QoS Manager can choose between achieving E2EMaxDelayHigh of 500 or 900, then 900 is preferable because it will typically pose a lower burden on the resources. Since 500 is also allowed, the E2EMaxDelayLow is therefore NOT the minimal delay.

The E2EMaxDelayHigh is returned to the Control Point. This specific information is computed by the QosManager Service after the admission at the QosDevice Services. If a new QoS Manager joins the network, it can only retrieve per-QoS Segment information from the QosDevice Services. It therefore has to calculate the actual E2EMaxDelayHigh itself.

6.5.2 Determination of adjacent QosDevice services within a QoS Segment

The Resource argument to the QD:AdmitTrafficQos() action and QD:UpdateAdmittedQos() action contains the adjacency of QosDevice Services. The Adjacency determination is explained in Clause 4.4.

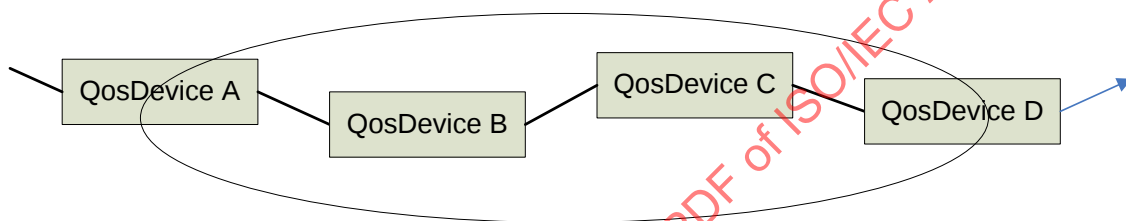


Figure 15 — Example of Adjacent QosDevice services

As a first example consider Figure 15 with the traffic stream flowing from A to D. The QoS Manager provides the following information to the respective QosDevice Services.

Table 2 — Devices A, B, C, D all implement QosDevice Service

<u>QosDevice</u> Service	<u>QosDevice</u> Service Downstream?	<u>QosDevice</u> Service Upstream?
A	<u>1</u>	<u>0</u>
B	<u>1</u>	<u>1</u>
C	<u>1</u>	<u>1</u>
D	<u>0</u>	<u>1</u>

We will now look at another example. Consider Figure 16 where device B and D do not implement the QosDevice Service. Here the QoS Manager provides the following information to the respective QosDevice Services.

Table 3 — Only Devices A and C implement QosDevice Service

<u>QosDevice</u> Service	<u>QosDevice</u> Service Downstream?	<u>QosDevice</u> Service Upstream?
A	<u>1</u>	<u>0</u>
C	<u>0</u>	<u>1</u>

There is a QosDevice Service downstream of QosDevice Service A (namely C) even though it is *not* a direct neighbor of A. For the determination of the values in the table, the devices that do not implement the QosDevice Service are irrelevant for the purpose of filling this table.