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Information technology – UPnP Device Architecture – Part 10-1: Quality of Service Device Control Protocol – Quality of Service Architecture



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INFORMATION TECHNOLOGY – UPNP DEVICE ARCHITECTURE –

Part 10-1: Quality of Service Device Control Protocol 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.

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UPnP Document Title	**ISO/IEC 29341 Part**
UPnP Device Architecture 1.0	ISO/IEC 29341-1
UPnP Basic:1 Device	ISO/IEC 29341-2
UPnP AV Architecture:1	ISO/IEC 29341-3-1
UPnP MediaRenderer:1 Device	ISO/IEC 29341-3-2
UPnP MediaServer:1 Device	ISO/IEC 29341-3-3
UPnP AVTransport:1 Service	ISO/IEC 29341-3-10
UPnP ConnectionManager:1 Service	ISO/IEC 29341-3-11
UPnP ContentDirectory:1 Service	ISO/IEC 29341-3-12
UPnP RenderingControl:1 Service	ISO/IEC 29341-3-13
UPnP MediaRenderer:2 Device	ISO/IEC 29341-4-2
UPnP MediaServer:2 Device	ISO/IEC 29341-4-3
UPnP AV Datastructure Template:1	ISO/IEC 29341-4-4
UPnP AVTransport:2 Service	ISO/IEC 29341-4-10
UPnP ConnectionManager:2 Service	ISO/IEC 29341-4-11
UPnP ContentDirectory:2 Service	ISO/IEC 29341-4-12
UPnP RenderingControl:2 Service	ISO/IEC 29341-4-13
UPnP ScheduledRecording:1	ISO/IEC 29341-4-14
UPnP DigitalSecurityCamera:1 Device	ISO/IEC 29341-5-1
UPnP DigitalSecurityCameraMotionImage:1 Service	ISO/IEC 29341-5-10
UPnP DigitalSecurityCameraSettings:1 Service	ISO/IEC 29341-5-11
UPnP DigitalSecurityCameraStillImage:1 Service	ISO/IEC 29341-5-12
UPnP HVAC_System:1 Device	ISO/IEC 29341-6-1
UPnP HVAC_ZoneThermostat:1 Device	ISO/IEC 29341-6-2
UPnP ControlValve:1 Service	ISO/IEC 29341-6-10
UPnP HVAC_FanOperatingMode:1 Service	ISO/IEC 29341-6-11
UPnP FanSpeed:1 Service	ISO/IEC 29341-6-12
UPnP HouseStatus:1 Service	ISO/IEC 29341-6-13
UPnP HVAC_SetpointSchedule:1 Service	ISO/IEC 29341-6-14
UPnP TemperatureSensor:1 Service	ISO/IEC 29341-6-15
UPnP TemperatureSetpoint:1 Service	ISO/IEC 29341-6-16
UPnP HVAC_UserOperatingMode:1 Service	ISO/IEC 29341-6-17
UPnP BinaryLight:1 Device	ISO/IEC 29341-7-1
UPnP DimmableLight:1 Device	ISO/IEC 29341-7-2
UPnP Dimming:1 Service	ISO/IEC 29341-7-10
UPnP SwitchPower:1 Service	ISO/IEC 29341-7-11
UPnP InternetGatewayDevice:1 Device	ISO/IEC 29341-8-1
UPnP LANDevice:1 Device	ISO/IEC 29341-8-2
UPnP WANDevice:1 Device	ISO/IEC 29341-8-3
UPnP WANConnectionDevice:1 Device	ISO/IEC 29341-8-4
UPnP WLANAccessPointDevice:1 Device	ISO/IEC 29341-8-5
UPnP LANHostConfigManagement:1 Service	ISO/IEC 29341-8-10
UPnP Layer3Forwarding:1 Service	ISO/IEC 29341-8-11
UPnP LinkAuthentication:1 Service	ISO/IEC 29341-8-12
UPnP RadiusClient:1 Service	ISO/IEC 29341-8-13
UPnP WANCableLinkConfig:1 Service	ISO/IEC 29341-8-14
UPnP WANCommonInterfaceConfig:1 Service	ISO/IEC 29341-8-15
UPnP WANDSLLinkConfig:1 Service	ISO/IEC 29341-8-16
UPnP WANEthernetLinkConfig:1 Service	ISO/IEC 29341-8-17
UPnP WANIPConnection:1 Service	ISO/IEC 29341-8-18
UPnP WANPOTSLinkConfig:1 Service	ISO/IEC 29341-8-19
UPnP WANPPPConnection:1 Service	ISO/IEC 29341-8-20
UPnP WLANConfiguration:1 Service	ISO/IEC 29341-8-21
UPnP Printer:1 Device	ISO/IEC 29341-9-1
UPnP Scanner:1.0 Device	ISO/IEC 29341-9-2
UPnP ExternalActivity:1 Service	ISO/IEC 29341-9-10
UPnP Feeder:1.0 Service	ISO/IEC 29341-9-11
UPnP PrintBasic:1 Service	ISO/IEC 29341-9-12
UPnP Scan:1 Service	ISO/IEC 29341-9-13
UPnP QoS Architecture:1.0	ISO/IEC 29341-10-1
UPnP QosDevice:1 Service	ISO/IEC 29341-10-10
UPnP QosManager:1 Service	ISO/IEC 29341-10-11
UPnP QosPolicyHolder:1 Service	ISO/IEC 29341-10-12
UPnP QoS Architecture:2	ISO/IEC 29341-11-1
UPnP QOS v2 Schema Files	ISO/IEC 29341-11-2

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UPnP Document Title	ISO/IEC 29341 Part
UPnP QosDevice:2 Service	ISO/IEC 29341-11-10
UPnP QosManager:2 Service	ISO/IEC 29341-11-11
UPnP QosPolicyHolder:2 Service	ISO/IEC 29341-11-12
UPnP RemoteUIClientDevice:1 Device	ISO/IEC 29341-12-1
UPnP RemoteUIServerDevice:1 Device	ISO/IEC 29341-12-2
UPnP RemoteUIClient:1 Service	ISO/IEC 29341-12-10
UPnP RemoteUIServer:1 Service	ISO/IEC 29341-12-11
UPnP DeviceSecurity:1 Service	ISO/IEC 29341-13-10
UPnP SecurityConsole:1 Service	ISO/IEC 29341-13-11

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1. Glossary

Access Domain

A set of LAN or MAN stations together with interconnecting data transmission media and related equipment (e.g., connectors, repeaters), in which the LAN or MAN stations use the same MAC protocol to establish the sequence of stations that are in temporary control of the shared transmission media.

Access Priority

The Access Priority is a parameter that indicates the priority handling when accessing the communication resource. The range of access priorities is defined by the layer 2 networking technology.

Best Effort

A general method of accessing a network communications medium to deliver a message. Best effort access is not guaranteed, and therefore the message may not get delivered. Many communication protocols mediums use this approach. Higher layers of protocol are needed to provide reliability or QoS. Best Effort is typically the default grade of service provided in a network when no specific QoS is requested.

Bridge

A functional unit that interconnects two or more LANs that use the same Data Link layer protocols above the MAC sublayer, but can use different MAC protocols

Hub

A device, with two or more physical ports, that forwards all traffic received on any individual port to all other ports. This device is also referred to as a “repeater”. In a home network, a hub connects networks segments of the same physical medium.

IGD

Internet Gateway Device: a border device physically connects the Home LAN with a WAN. This device performs routing. QoS mechanisms associated with routing are not addressed by this architecture, the IGD may present a QosDevice interface on the Home LAN.

Intermediate Device

An intermediate device is physically connected between the Source and Sink device data flow. There may be more than one intermediate device in the Source to Sink connection.

Path

The physical course that traffic will flow on from source to sink. For UPnP QoS, a path must reside within a single IP subnet, but a path may comprise multiple segments.

Packet Priority

The Packet Priority is a layer 2 parameter that indicates the priority handling requested by the originating service. Typically this parameter is part of a packet header and indicates the relative importance of the packet compared to other packets. It is used to differentiate packets to determine which are given preferential access to the communication medium. This parameter is typically mapped to an Access Priority value supported by the network device.

Parameterized Services

Parameterized services refer to a general methodology for obtaining QoS. A contract is made with the network using a set of parameters that define the application's traffic requirements. The parameters typically include bandwidth and delay.

Policy Management

A function that makes decisions on the traffic streams allowed to use network resources.

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Prioritized Services

Prioritized services refer to a general methodology for providing QoS by differentiating traffic. Messages types are grouped by order of importance and assigned a priority. Message types assigned a higher priority are given preferential access to the communications medium. There are no limits to the number of messages using a given priority, and the bandwidth of the network may be less than the bandwidth of the messages.

Quality of Service (QoS)

The term QoS refers to a broad collection of networking capabilities and techniques. The goal of QoS is to improve the user experience of a network's ability to deliver predictable results for sensitive applications such as audio, video, and voice applications.. Elements of network performance within the scope of QoS often include bandwidth (throughput), latency (delay), and error rate. There are two broad classes of QoS: data reliability and temporal reliability. Each makes different demands on network technologies. This architecture is primarily concerned with delivering temporal reliability

Router

A device, with two or more physical ports, that makes port to port traffic forwarding decisions based on layer 3 information (source and destination IP addresses).

Segment

A segment refers to a section of a network that shares a common physical medium. The boundaries of a network segment are established by devices capable of regulating the flow of traffic into and out of the segment. This includes routers, bridges, hubs, switches, adapters (e.g., PCI, PCCard, or USB NICs). With particular relevance to UPnP QoS, a segment is typically a physically distinct portion of a larger network that is in turn defined logically by devices residing on a common IP subnet.

Sink Device

A Sink device provides media data receiving, playback, storage, or rendering capabilities. Some examples include TV monitors, Stereo and Home Theaters, PDAs, Wireless Monitors, recordable DVDs, and Printers.

Source Device

A Source device provides media transmission and data sourcing capabilities. Examples include STBs, PVRs, PCs, Music Servers, Broadcast Tuners and Video Imaging Capture Devices. It acts as the source of a traffic stream, regardless of other functions on the device.

Subnet

Subnet as defined in IETF Zeroconf in RFC 3927:

ftp://ftp.isi.edu/internet-drafts/draft-ietf-zeroconf-ipv4-linklocal-18.txt .

Traffic Class

The Traffic Class indicates the kind of traffic in the traffic stream. The Traffic Class is used to distinguish, for example, audio from video. The distinction is at the application layer and the Traffic Class is mapped into the applicable layer 2 representations for the technology bearing the stream. An example is the mapping in 802.1D, Annex G.

Traffic Identifier (TID)

A Traffic Identifier is a set of information that uniquely identifies a set of data packets as belonging to a traffic stream. This information is typically used by a packet classifier function to associate a Traffic Specification's QoS contract to the service provided to the Traffic stream. Other technologies may refer to this as a Filter Spec (RFC2205) or Traffic Classifier (802.11e).

Traffic Specification (TSPEC)

A Traffic Specification contains a set of parameters that define the characteristics of the traffic stream. The TSPEC may be used to define the operating requirement for carrying the traffic stream and may define the operation of the packet scheduling function.

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Traffic Stream (TS)

Traffic Stream is a unidirectional flow of data that originates at a source device and terminates at one or more sink device(s).

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2. Introduction

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

- QosDeviceService
- QosPolicyHolder Service
- QosManager Service

It should be noted that while UPnP QoS defines three new 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 may use any UPnP device as a container for the services defined in UPnP QoS. The Control Points and QoS Management Entities must look for UPnP QoS Services embedded in all UPnP device types.

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

2.1. Referenced Specifications

Unless explicitly stated otherwise herein, implementation of the mandatory provisions of any standard referenced by this specification shall be mandatory for compliance with this specification.

[Annex_G] – IEEE 802.1D-2004, Annex G, *IEEE Standard for Information technology - Telecommunications and information exchange between systems - IEEE standard for local and metropolitan area networks - Common specifications - Media access control (MAC) Bridges*, 2004.

[XML] – *Extensible Markup Language (XML) 1.0 (Second Edition)*, T. Bray, J.Paoli, C. M. Sperberg-McQueen, E Maler, eds. W3C Recommendations, 6 October 2000.

[QM] – UPnP™ QosManager:1 Service Document:

[QD] – UPnP™ QosDevice:1 Service Document:

[QPH] – UPnP™ QosPolicyHolder:1 Service Document:

[AV] – UPnP™ AV Architecture Document V0.83

[DEVICE] - *UPnP Device Architecture, version 1.0*.

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3. Architecture Overview

There are three elements (services) in the UPnP QoS architecture. These are the QosPolicyHolder Service[QPH] , QosManager Service[QM] and QosDevice Service[QD] . All three are shown in the following figure. The numbers in parenthesis indicate the order of the QoS actions.

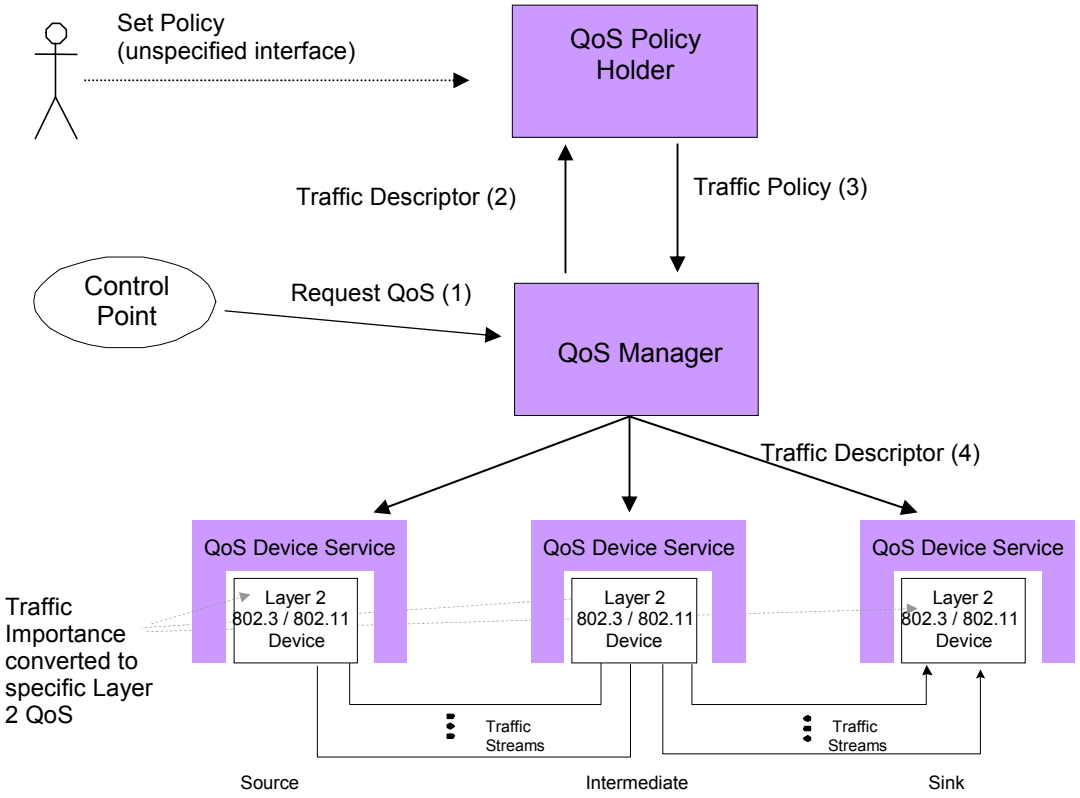

Figure 1 – UPnP QoS Architecture Overview

The following describes an overall architecture of the QoS subsystem and the interaction between various components. To illustrate the relationships of various QoS components, an example scenario with a simple sequence of setup steps is described below. The detailed operations are described in section 5.

In this scenario, the Control Point (CP) application is assumed to have the knowledge of source, sink and content to be streamed, along with its Tspec. After the CP discovers the source and, sink (step 1) along with content Tspec, it requests a QosManager in the network to setup a QoS traffic stream. (step 2). The CP creates a TrafficDescriptor structure and passes it to the QosManager Service. The QosManager component, acting as a control point, requests the QosPolicyHolder service to provide appropriate policy for the TrafficDescriptor (step 3). Based on this policy, the QosManager, configures the QosDevices for handling the new traffic (step 4).

The QosPolicyHolder Service provides Policy for the network on which it resides. That is, the QosPolicyHolder can be used to set the relative importance of a particular traffic stream by returning a TrafficImportanceNumber and a UserImportanceNumber (TrafficPolicy). The TrafficImportanceNumber in turn, is conveyed to layer 2 QosDevices by the QosManager and is used in deriving the technology specific layer 2 access priority. For Parameterized Services, the allocation of resources for QoS instances, by a QoS Device, is determined by the UserImportanceNumber.

The QosManager communicates with the QosPolicyHolder, if present, to get the TrafficImportanceNumber (part of TrafficPolicy) for a traffic stream request. If there is no QosPolicyHolder, then a default policy is applied based on the TrafficClass supplied by the ControlPoint. Additionally, the QosManager may perform admission control for a traffic stream on behalf of a QosDevice, if AdmissionPolicy is enabled by the QosPolicyHolder. If admission control is performed, the UserImportanceNumber may be considered.

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Fundamentally, UPnP QoS operates on a traffic stream that flows between two or more devices. A traffic stream is viewed as a uni-directional flow from a source device to a sink device, possibly passing through intermediate devices. The QosDevice Service exists within one or more layer-2 devices to receive and apply the TrafficImportanceNumber (e.g., implied access priority) for a traffic stream.

The internal mechanism used by the QosDevice for applying the TrafficImportanceNumber is not defined by UPnP. For a prioritized environment, it is envisioned that either an application on the source QosDevice directly tags the packets to be transmitted or there is a classifier function in the QosDevice that examines and tags packets

It should be noted that a fundamental assumption for UPnP QoS is that every device on the home network will be on the same IP subnet. Therefore routing between devices in the home LAN is out of scope for UPnP QoS.

This section is meant as a brief overview of the UPnP QoS Architecture. The following section will explain the motivation behind UPnP QoS. It has also introduce some key concepts and terms that will be more fully explored in the following sections of this document.

3.1. Motivation

3.1.1. Policy Management

Policy management provides a way to allocate network resources, e.g., network bandwidth, according to a set of defined preferences. It provides criteria for resolving conflicts when applications simultaneously compete for the resources. Policy is the basis for responding to questions such as these:

- Who and what can access which resources on the network?
- What is the highest importance traffic or application that is in use, what is the lowest importance traffic, and what levels of traffic are in between?
- What traffic must have guaranteed delivery?
- How is bandwidth allocated to ensure guaranteed delivery?
- What traffic is eligible to be discarded when the network becomes busy and congested?

A policy-based management system allows an individual or entity to define rules, based on these types of questions and to manage them in the context of the policy system. These rules are then applied to network resources and requests based upon a set of pre-defined criteria and/or conditions such as network address, application type and/or bandwidth needs and availability.

UPnP QoS is a policy based management system. The QosPolicyHolder Service, in particular, provides a centralized mechanism for enabling or disabling Admission Policy for the entire network and for classifying traffic according to information provided in the request for Quality of Service for a particular traffic stream. The type of information is provided in the Traffic Descriptor includes, among other items, traffic class, the source and destination network IP addresses for the stream, and the protocol. Whenever a QoS resource request is made, it is forwarded to the QosPolicyHolder Service (if present) by the QosManager Service. The QosPolicyHolder Service then examines the information provided in the request and returns the importance, in TrafficPolicy, that shall be given to the traffic stream.

There were several goals taken into account in the design of the UPnP QoS Architecture and in particular the QosPolicyHolder Service. These included:

1. Consistent and predictable classification of a traffic stream.
2. Allow for flexibility in QosPolicyHolder implementation, to meet the diverse needs of applications and requirements.

3.2. Key Concepts

3.2.1. Admission Control

Admission control is the procedure followed to permit the instantiation of a traffic flow at any of the following QoS capable devices: a source, zero or more intermediate devices on a traffic stream's path, or a sink. This procedure is based on a device's resources and is a go/no-go decision for a single traffic flow instantiation request. The decision is made based on the instantaneous state of the device. The procedure may be executed by

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the QosManager or the QosDevice, depending on the device's advertised capabilities. In the UPnP QoS version 1.0 Specification, QosDevice Admission Control is not supported.

3.2.2. Admission Policy

Admission Policy is the procedure followed by the QosManager, which is responsible for managing the end to end instantiation of a traffic flow. This procedure uses policy information, obtained from the QosPolicyHolder Service, to determine the continuing viability of existing end to end traffic instances. If policy permits, existing end-to-end traffic stream instances may be modified or de-committed by the managing entity (QosManager), in order to allow the instantiation of the prospective traffic flow. The policy information used for making decisions is AdmissionPolicy, UserImportanceNumber and TrafficImportanceNumber.

3.2.3. Traffic Descriptor

The TrafficDescriptor is composed of a TrafficId and other pertinent information that must be provided by the initiator Control Point. It is the representation of a traffic stream for purposes of providing QoS.

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4. UPnP QoS Components

4.1. QosPolicyHolder Service

4.1.1. Role

The UPnP QosPolicyHolder Service is the repository of the QoS policy for a given Home LAN. This QoS Policy is configured by the user, or a third party on behalf of the user, to indicate the treatment of all traffic on the Home LAN. The QosPolicyHolder Service provides a UPnP defined interface for a QosManager to access the Home LAN QoS policies. The Policy within the QosPolicyHolder Service is populated in a non-specified manner that is out of scope of UPnP QoS specifications. For example, methods such as an HTML GUI or other vendor dependent applications could be used.

The main function of this service is to judiciously allocate the use of traffic importance numbers by applications 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 loose differentiation.

4.1.2. Traffic Stream QoS Policy Description

The QoS traffic policy (TrafficPolicy) consists of 3 elements, namely *AdmissionPolicy* (a Boolean value), *TrafficImportanceNumber* (an integer in the range of 0-7), *UserImportanceNumber* (an integer in the range of 0-255).

If a QosPolicyHolder administrator chooses to set AdmissionPolicy (enable/disable) to enable, as described in Section 3.2.2, the QosManager enforces admission policy for the traffic streams being setup.

The *TrafficImportanceNumber* indicates a traffic stream's level relative importance priority as described in Section 3.1.

The *UserImportanceNumber* will be used by the QosManager as the basis for admission policy decisions when the network resources are saturated. The UserImportanceNumber allows the QosManager to admit new requests or revoke previous requests so that the traffic streams with higher UserImportantNumbers are accommodated first. This value allows users the ability to fine tune their preferences for particular types of traffic that otherwise might have had the same TrafficImportanceNumber. The UserImportanceNumber value is applicable only when A*dmissionPolicy* is enabled. The value of 255 indicates highest importance and the value 0 indicates lowest importance. In the case where two or more streams have the same UserImportanceNumber value, a first come first serve policy is applied to them

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

The UPnP QoS architecture only allows a single policy holder in the home network. When there are multiple or no QosPolicyHolder Services in the home network, the behavior of QosManager is described in section 4.2 (QosManager).

The vendor of each QosPolicyHolder Service device should provide a mechanism for the user to enable or disable the QosPolicyHolder Service. This is needed to manage the case where multiple QosPolicyHolder services are available on the home network. The UPnP QoS framework does not define any specific mechanism for selection or activation of a QosPolicyHolder service.

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4.2. QoS Manager

4.2.1. Role

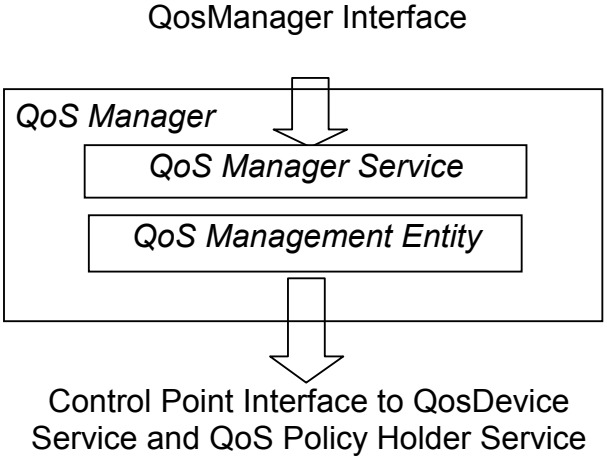

Figure 2 – QoS Manager Function and Interfaces

The QoS Manager Function is an essential part of the UPnP QoS framework. The QoS Manager Function is a combination of a QosManager Service and a QoS Management Entity as shown in Figure 2. The QoS Management Entity provides the Control Point functionality that discovers and controls QosDevice services and the QosPolicyHolder Services running on the network. The QoS Management Entity is responsible for requesting and releasing the quality of service assigned to various network traffic streams. The interface between the QoS Management Entity and the QosManager Service is device dependent and not defined by the UPnP QoS specifications.

In the remainder of the document the term "QoS Manager" may be used to refer to the QosManager Service, the QoS Management Entity or the collective functionality.

4.2.2. Behavior

When a QosManager completes setting up a traffic stream, the traffic related information is stored in the QosDevices on the traffic stream's path (source, intermediate, and/or sink). All QosDevices in the network path will store the traffic descriptor (more details in the QosDevice Service section). Consequently, any QosManager can query the QosDevices and determine the state of the traffic stream.

An AV Control Point or Control Point (for non AV scenarios) will request the QosManager Service to setup QoS by providing a TrafficDescriptor. The QosManager service will retrieve admission and traffic QoS policy from the QosPolicyHolder Service and, possibly after determining the network path, will setup all appropriate QosDevice services.

The QosManager service provides an interface (RequestTrafficQos action) 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 is not successful, then it returns a corresponding error code.

4.2.3. Dealing with Policy

The QosManager interacts with the QosPolicyHolder Service in these ways to deal with policy.

- If there is one QosPolicyHolder Service on the network it must be used as the source of policy information
- If there is more than one QosPolicyHolder service, then the QosManager must use the default policy described in [QM] .

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- If there are no QosPolicyHolder services on the network, then the QosManager must use the default policy described in section [QM] .

After completing the action, RequestTrafficQoS, the QosManager will also return the number of QosPolicyHolders (in addition to other return parameters) that are visible to the QosManager.

4.2.4. QoS Update

In order to update the QoS for a traffic stream the QosManager will have to release the QoS for that traffic stream first and then setup QoS again for the requested traffic descriptor.

4.3. QosDevice Service

4.3.1. Role

The QosDevice Service is a function typically implemented in QoS capable source, sink or intermediate network device. A QosDevice Service is responsible for managing the device's network resources for traffic streams and returning the state of the device.

4.3.2. Behavior

The QosDevice Service provides an interface for Control Points to execute actions on the device to instantiate QoS for traffic streams, to query the QoS capabilities and state of the device, and to register for events that the device generates. Typically, a QoS Management Entity acts as a Control Point for QosDevice Service.

A UPnP QosDevice will expose its static QoS capabilities through the GetQosDeviceCapabilities interface action. The static capabilities include type of Native QoS support, such as: "Prioritized", "Parameterized", or "BestEffort". In the current UPnP QoS Specifications, "Parameterized" QoS is not supported. Other capabilities include maximum PHY bandwidth, network TechnologyType, MAC address, InterfaceId and AdmissionControlSupported. In the current UPnP QoS Specifications, AdmissionControlSupported shall not be enabled.

The run time QoS state of the device exposed through the GetQosState action. Since the QosManager is stateless and all of the traffic streams' related information is stored in each QosDevice on a traffic stream's path, the GetQosState interface provides information about its currently active traffic streams by returning a list of active TrafficDescriptors.

SetupTrafficQos action associated with QosDevice service allows the QoS Management entity to setup QoS associated with a particular traffic. ReleaseTrafficQos action associated with QosDevice service allows the Management entity to release QoS associated with a particular traffic. If the QoS Management entity is interested in updating the existing QoS associated with a stream, it is expected to first call the ReleaseTrafficQos action, followed by an SetupTrafficQos action.

The topology information associated with the QosDevice (in terms of its MAC table entries) is exposed via the GetPathInformation action.

Finally, GetQosDeviceInfo action allows the QosDevice to expose the port number and protocol associated with a particular traffic stream.

4.3.3. Setup Traffic QoS

The QosManager uses the TrafficDescriptor and calls the SetupTrafficQos action on the QosDevice service to set up QoS for the traffic stream identified by the TrafficId in the traffic descriptor.

4.3.4. Traffic Admission Control

In response to the action GetTrafficPolicy, the QosPolicyHolder returns the admission policy for the home network in the AdmissionPolicy state variable. If the value of the state variable is "Enabled", the QosManager may perform end-to-end network wide admission control in order to allocate network resources such as

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bandwidth, airtime, etc. to provide the required QoS service as specified in the optional Tspec. The QosManager may use the associated UserImportanceNumber to reject or allocate new traffic streams and/or revoke existing traffic streams. If the value of the AdmissionPolicy state variable is “Disabled”, the QosManager must pass the traffic stream’s TrafficImportanceNumber to the relevant QosDevices. Device level admission control is not part of this version of UPnP QoS specification. The QosDevice parameter AdmissionControlSupported is specified for future extensions to this specification.

4.3.5. Path Information

The QosDevice service provides an interface to provide information regarding its neighboring devices that are reachable through each of its active interface. This information is very useful for QosManager service to correctly detect the network segment topology corresponding to the traffic stream path.

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5. System Operation

An overview of the operational flow is given below, more detailed information is provided in the related subsection.

1. Initiation of the QoS Setup for a traffic stream – The QosManager requires a minimum set[2] of information from an initiator Control Point to perform the setup. The method used to gather this information for different usage environments is described in the initiation process.

2. Determination of Policy for the traffic stream – The QosManager will determine the appropriate policy by requesting this information from the QosPolicyHolder service. If a single QosPolicyHolder is not available then default policy will apply.

3. Determination of QosDevice Services that should be configured – Based on the source and destination information for the traffic stream the QoS Management Entity will determine which QosDevice Services will play a role in the transport of the traffic stream.

4. Configuration of QosDevice – the QoS Management Entity will interact with each applicable QosDevice 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, and possibly in future versions - QosDevice-based admission control.

5. Feedback of the results of the QoS setup to the initiator Control Point of the QosManager – the success or failure of setup is provided to allow user feedback or other possible corrective actions.

5.1. Initiation of QoS Setup

The initiator Control Point may first select a QosManager Service. If the initiator Control Point does not select a QosManager Service, then it must implement or provide a QoS Management Entity. There may be zero or more QosManager Services in the home network. These are known through standard UPnP discovery methods. The method for selection of the QosManager is outside the scope of the UPnP QoS specification.

When a QosManager Service is selected, its operation is triggered through the RequestTrafficQoS action. This provides the QosManager with a (partially complete) TrafficDescriptor. Upon completion of the action, the QosManager returns the TrafficHandle, NumPolicyHolders and (an updated) TrafficDescriptor to the initiator 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. A value other than 1 indicates that the default policies have been used by the QosManager. A value of one indicates that the policy provided by the QosPolicyHolder Service has been used .

The information provided in the TrafficDescriptor by the initiator Control Point and the related process steps are described in the following subsections. The process is different when the initiator is a generic Control Point or an independent AV Control Point.

5.1.1. Generic Control Point

In the case of a generic initiator, the UPnP QoS framework requires the initiator Control Point to manage the binding between the traffic stream and the TrafficDescriptor. This means that the initiation of the QosManager is done by a Control Point that has knowledge of the setup of the transport method (for example, TCP or UDP which is out of band to UPnP QoS). It must be able to provide the QosManager with the complete TrafficId information and the Tspec.

The generic initiator case is applicable to the following applications:

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[2] see the Traffic Descriptor Matrix in QosManager Service document[QM] for examples

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- UPnP AV Services, two box model

In the two box model there is only a Media Server device (MSD) and a Media Server control point. The device that hosts the Media Server control point (MSCP) is typically 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 before or after the establishment of the traffic stream from the server.

- Generic case

Any application is able to initiate the QoS setup as long as it can provide the information needed by the QosManager Service.

5.1.2. Independent AV Control Point

The AV Control Point case refers to the situation where there is a Control Point independent from the Media Render device (MRD). 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 may be unaware of the complete TrafficId as the port numbers may be unknown to the AV Control Point. The QosDevice action GetQosDeviceInfo can be used by the QosManager to query the appropriate QosDevice for the port numbers on the basis of an (incomplete) TrafficDescriptor. When the MediaServerConnectionId and MediaRendererConnectionId are provided these may be used by the QosDevice to correctly identify the connection.

The QosManager action *RequestTrafficQos* offers the ability to take an ordered list of Tspecs and have the QosManager select the most-preferred Tspec that can be supported by the network conditions. However in practice, use of this capability is limited due to the fact that the complete traffic ID may not be known before the setup of the transport session or may not be the same for all Tspecs. Since the port numbers are typically independent from the URI and known in the devices that will setup the transport connection, it is possible for the QosManager to have sufficient TrafficId information to complete the QoS setup process via the GetQosDeviceInfo action on the MediaRenderer and MediaServer. In this version of the QoS framework the use of this feature is restricted to cases where the port numbers are consistent between different Tspecs. Finally the AV Control Point is responsible for ensuring that the URI corresponding to the selected Tspec is selected via SetAVTransportURI.

5.1.3. Determination of TrafficId

The initiation of QoS with RequestTrafficQos can be done before or after full knowledge of the TrafficId is available. A summary of the issues in each of these cases is outlined below.

- Before establishment of the Traffic Stream

  In this case, only a minimum amount of TrafficId information may be available to the Control Point initiating the QoS request. Before the traffic stream is established, the port numbers are typically not known, so typically only the source and destination IP addresses can be provided. This approach has the advantage of setting up of the QoS for the traffic stream before the stream flow begins. This means that if there are insufficient resources on the network for the stream, this can be known before the content is streamed and unsatisfactory performance is observed by the user. The initiator ControlPoint can then take corrective measures. A disadvantage of this approach is the need for a longer setup process. After the traffic stream is established, the initiator Control Point can determine the remaining information, such as port numbers, and use UpdateTrafficQos to pass the remaining information to the QosManager for distribution to the QosDevice Services.

- After establishment of the Traffic Stream

  In this case the full TrafficId information is provided, consisting of source and destination IP addresses and port numbers. This has the advantage of simplifying the setup process but has the disadvantage of having the stream start without having QoS applied to it in the network

The preferred approach is for the full set of TrafficId information to be provided based on the establishment of the traffic stream but before the start of the transfer. This ability to do this is dependent on the transport protocol and its use by the application.

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5.1.4. Creation of Optional Traffic Specification (Tspec)

The initiator Control Point is responsible for providing the optional content dependent Traffic Specification (Tspec) parameters to the QosManager. These parameters define the performance characteristics desired as seen by the application receiving the content. The generation of the Tspec parameters is left to the initiator Control Point but the UPnP QoS framework provides a standard method for the parameters to be stored in Content Directory Service (CDS) of the UPnP Media Server. This information can be used in the case where the UPnP AV services is used, otherwise it is up to the initiator Control Point to derive and provide this information.

A summary of the options available for generation of the Tspec parameters is provided below:

- Retrieved from CDS – the resource element in CDS may provide a set of Tspec parameters. This is the preferred method for traffic specification creation if this information is available.
- MIME-type and other info in CDS – the MIME-type element that is part of the ProtocolInfo and properties such as res@bitrate can be used to derive the TSPEC parameters.
- Derived from the content itself – retrieval of the content itself can be used to determine the Tspec parameters. However this requires the intelligence to understand the content, although this will be typical for rendering devices.

Application dependent – an application or protocol may provide other means for deriving this information.

5.2. Determination of Policy for the Traffic Stream

The QosManager uses the TrafficDescriptor information to determine policy for the traffic stream. It will use the default policy if there is no QosPolicyHolder Service or more than one QosPolicyHolder Service. It must use the QosPolicyHolder Service to retrieve the policy for the stream when the service is available.

5.2.1. QosPolicyHolder Service

The QosManager must use the GetTrafficPolicy action of the QosPolicyHolder Service to retrieve the policy for the traffic stream defined by the information in the TrafficDescriptor. The QosPolicyHolder Service will provide three pieces of information: TrafficImportanceNumber, UserImportanceNumber and AdmissionPolicy. Further definition of these parameters is provided in section 4.1.2 of this document. The use of these parameters in the traffic stream setup process is described briefly:

- AdmissionPolicy - determines if end-to-end admission control is used in the home network.
- TrafficImportanceNumber – In a prioritized case, this parameter is used to determine the packet priority value for the traffic stream. The QoS Manager's QoS Management Entity must provide it to the QosDevice Services, when the AdmissionPolicy is "Enabled", to allow tagging of the packets appropriately.
- UserImportanceNumber - provides a relative rating of the traffic stream's user importance compared to that of the other traffic streams. Its value must be used by the QosManager to determine the traffic streams that are allowed on the network in the case where there are insufficient resources. It is only used in the case when AdmissionPolicy is enabled. When used, the QosManager must compare the UserImportanceNumber values of the new traffic stream to that of the existing streams and modify network resource allocation to allow the traffic streams with the highest UserImportanceNumber. In the case where the UserImportanceNumber is the same, a first come first serve approach is used to determine which streams get the network resources.

5.2.2. Default Policy

The following default policy must be used by the QosManager in the case where there is no QosPolicyHolder Service or more than one QosPolicyHolder Service exists on the network.

The default value for AdmissionPolicy is "enabled" state.

The TrafficImportanceNumber default is based on the TrafficClass. This default mapping of Traffic Class to TrafficImportanceNumber is defined in the QosManager Service document. If the TrafficDescriptor does not

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contain a valid TrafficClass then the QosManager Service must treat that traffic stream as traffic class type "Other".

The default UserImportanceNumber is 0, the lowest value.

5.3. Determination of QosDevice Services that should be configured

To setup QoS for the traffic stream, the QosManager may determine the devices that are involved in the transport of the traffic stream and the type of QoS setup that is required. Determination of the devices is done via a path discovery mechanism that may include use of QD[3]:GetPathInformation.

5.3.1. Path Determination (Optional)

The QosManager may use the TrafficId information together with the response from QD:GetPathInformation received from each QosDevice Service to determine which devices are on the path. This information may also used to determine the applicable network interfaces.

1. The QosManager 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.
2. The QoS Manager may then find the intermediate devices by :
    a. Looking up the MAC addresses corresponding to the Source and Destination IP addresses in the Traffic ID
    b. Getting the QD:GetPathInformation structure from every QosDevice Service available.
    c. Comparing the MAC addresses from the TrafficID to the DeviceReachableMacs in the QD:GetPathInformation Structures.

5.3.2. Setup Capabilities Determination

The QosManager uses the information in the previous step to determine the network capabilities for each device and interface on the path.

1. The QosManager uses the QD:GetQosDeviceCapabilities action on each device on the path. This returns the QosDeviceQosCapabilities XML structure.
2. The capabilities of each interface are extracted by matching the <interfaceId> value to corresponding values in the QosDeviceCapabilities XML structure. The following information is provided:
    - **TechnologyType**: Provide an indication of the networking technology type (e.g., 802.11, 802.3, etc.)
    - **AdmissionControlSupported**: This field indicates whether the interface on the device is capable of performing the device level admission control function.
    - **NativeQos**: Indicates if the interface support prioritized or best efforts QoS.
    - **MaxPhyRate**: indicates the maximum PHY rate of the interface.

5.4. Configuration of QoS Devices

The configuration of the QosDevices is controlled by the QoS Management Entity. Depending on the particular requirements of the traffic stream and capabilities of the QoS Devices on the path of the traffic stream, the QoS

[3] QD: QosDevice Service

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Management Entity can choose the appropriate setup. Some of the typical strategies that it may employ are described here.

5.4.1. Priority Setup Strategy

For most networks, configuring the traffic stream source device with the appropriate packet priority (TrafficImportanceNumber) is needed for setup of QoS. Intermediate devices should also be configured with the traffic stream's TrafficDescriptor.

5.4.2. Admission Control Strategy

If the AdmissionPolicy flag is enabled then the QosManager must perform network wide admission control of the traffic streams.

Device level admission control is not supported in UPnP QoS Version 1.0.

5.5. Run time Operation

5.5.1. Lease Management

TrafficDescriptor optionally includes 'Lease Time' for the QoS resources allocated to the traffic stream. It is up to the QosDevice service to enforce this constraint. If the QosManager intends to update the lease time of the traffic stream (TrafficleaseTime), then it requests a complete new traffic stream setup process again after it has released the QoS resources.

5.5.2. Traffic revocation

A ControlPoint may revoke a traffic stream by calling QM:ReleaseTrafficQos with the appropriate TrafficHandle.

5.5.3. Violation of TSPEC

Tspecs are not policed in this version of the UPnP QoS Framework.

5.5.4. The Use of Traffic Descriptor

Traffic Descriptor is an xml structure that is exchanged during the run time QoS negotiation described above. For details about how this structure is populated and used, please refer to QosManager Service description document, Appendix B.

5.6. Relationship to other UPnP Services and non UPnP Traffic Streams

5.6.1. UPnP IGD

UPnP QoS is seen as a complementary service that may be added to an IGD. While the IGD is concerned primarily with LAN to WAN connectivity, the UPnP QoS service allows it to participate within the local network for QoS on traffic streams it terminates for the Wide Area or for streams that may pass through any of its local interfaces. For example, it could be an intermediate QoS device for traffic that flows from a Wireless AP to a physical Ethernet interface or between two physical Ethernet interfaces. For streams that come from a LAN client that are destined for the WAN, or vice-versa, it can be a sink or source device.

To participate in UPnP QoS, the IGD need only implement the QosDevice service. A vendor implementing an IGD may choose to also implement a QosManager and QosPolicyHolder.

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In the case of a scenario where the traffic either originates or terminates on the WAN (i.e. WAN-to-LAN or LAN-to-WAN traffic) the QosBoundarySourceAddress and QosBoundaryDestinationAddress fields of TrafficDescriptor may be used. These values may be used by the QosManager for such tasks as path determination. In such a scenario, the Traffic Identifier field of TrafficDescriptor enumerates the real source / destination IP address of the stream (whether it is on the LAN or the WAN). In case where the traffic originates on the WAN and ends up on the LAN, the Control Point will specify the QosBoundarySourceAddress as the IP address of the IGD. In case where the traffic originates on the LAN and ends up on the WAN, the Control Point will specify the QosBoundaryDestinationAddress as the IP address of the IGD.

5.6.2. Legacy Devices

Legacy devices cannot be discovered nor managed via UPnP QoS. They may however, be able to process a Layer 2 priority that has been set by a QosDevice Service.

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6. Prioritized QoS

6.1. Management of Packet Priorities

The QoS Management Entity communicates TrafficImportanceNumber consistent with the QoS Policy being used. The following diagram depicts the sequence of messaging for the setting up QoS for a given traffic stream.

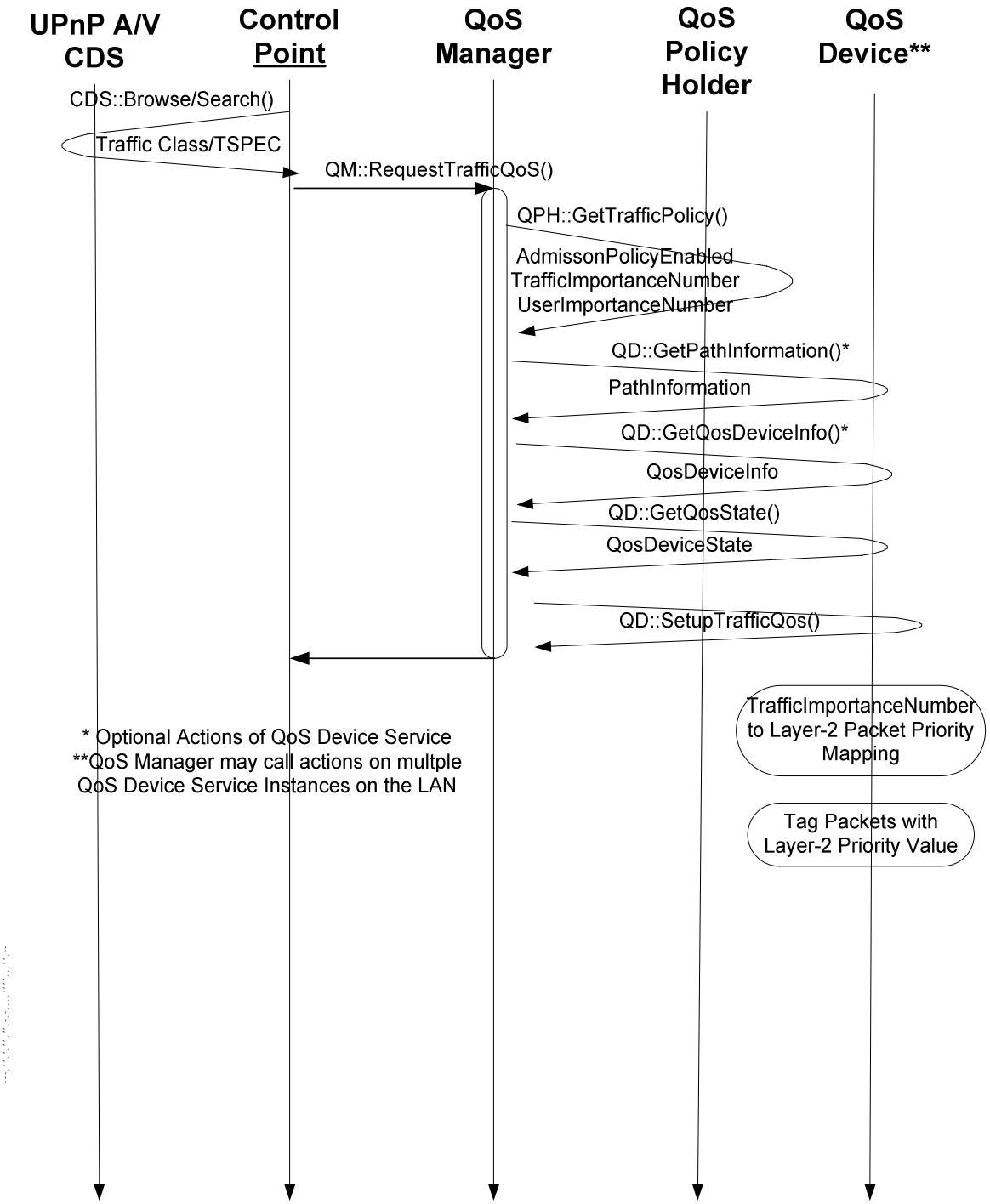

Figure 3 – Packet Priority Determination Flow

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The packet priority value used on a particular traffic stream is derived from the TrafficImportanceNumber. The packet priority value can be provided by any device (based on TrafficId) on the path of the traffic stream although it is typically required at the source device. This allows the packet tag to be assigned the correct priority value that is carried through the full path of the packet through the network.

The mapping of the TrafficImportanceNumber to the priority tag value used for the layer-2 network is not defined by the UPnP QoS Framework. This is dependent on the particular layer-2 technology type used. 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 packet tag value.

The TrafficImportanceNumber is determined by the QosPolicyHolder service. Based on Traffic Class and other information available in the traffic descriptor the QosPolicyHolder service provides the TrafficImportanceNumber. In the case where the QosPolicyHolder Service cannot be used, default policies are defined that must be used by the QosManager.

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7. Parameterized QoS

The term “Parameterized QoS” covers Quality of Service decisions and implementations on the basis of a set of QoS-parameters. There are two levels at which parameterized QoS can be employed. First, parameters can be used to specify the requirements of a traffic stream, e.g. that the average bit rate is 10 Mbit/sec, second these parameters can be used (typically at MAC and/or IP layer) to provide the appropriate packet scheduling for all traffic streams.

The UPnP QoS framework supports parameterized QoS, but currently only defines the parameter TrafficClass. The parameters are captured in the Tspec structure. In a CDS the attribute Tspec contains (a uri to) the Tspec parameters for the corresponding <res> element. Typically, there can be multiple <res>(s) per AV CDS item, each having its own Tspec. An Example is described below. The control point requesting QoS at a QosManager may extract the Tspec information for the item from an AV CDS or in an alternative way, for non AV scenarios. The QosManager may use the TspecList, together with the dynamic Qos state of the network obtained from the QosDevice(s) to come to a decision which <res> item is the most appropriate under the given network conditions. When the appropriate parameters are defined, a QosManager could take bandwidth, airtime, etc. in to account. When the active QosPolicyHolder does not switch off admission control, the QosManager can also decide not to admit this traffic stream altogether. It must be noted that admission control is subject to the importance ordering of the traffic stream via UserImportanceNumber(s). This may imply that if the UserImportanceNumber is high enough, the new traffic stream will be admitted but the QoS of other traffic streams may be revoked. When it is supported by the QosDevice, admission control may be performed by the device rather than the QosManager.

From the literature it is known that the traffic specification can be used for both a prioritized as well as a parameterized implementation. A prioritized implementation can be achieved by appropriately managing the TrafficImportance in the QosPolicyHolder. The UPnP QosDevice specification currently does not support parameterized-QoS devices nor does it support admission control at the device level. One may imagine that future versions of the QosDevice will include this support, allowing a QosDevice itself to manage its own resources. A QosDevice then could reserve the its resources as necessary to serve the traffic stream according to the presented Tspec(s) and to release the its resources when the traffic stream is revoked. This allows the resources can be reused for other traffic. For forward compatibility with such QosDevice(s) it is essential that a QosManager verifies the NativeQos and AdmissionControlSupported elements of the QosDevice’s QosDeviceCapabilities structure.

The following example describes the Tspecs in CDS and the use of indirection through a URI in CDS. We assume the normal UPnP name spaces are in effect and that an appropriate namespace q: is defined somewhere and is in effect for this example.

```
<item>
      …
       <res protocolInfo="http-get:*:video/mpeg:*"
      tspec="&lt;TrafficClass&gt;AV&lt;/TrafficClass&gt;&lt;q:MeanDataRate&
gt;20000000&lt;/q:MeanDataRate&gt;" …>
            http://1.2.3.4/file-highres.mpg
      </res>
       <res protocolInfo="http-get:*:video/mpeg:*"
      tspec="http://1.2.3.4/med-res-tspec" …>
            http://1.2.3.4/file-highres.mpg
      </res>
      <res protocolInfo="http-get:*:video/mpeg:*"
      tspec="&lt;TrafficClass&gt;AV&lt;/TrafficClass&gt;&lt;q:MeanDataRate&
gt;10000000&lt;/q:MeanDataRate&gt;" …>
            http://1.2.3.4/file-lowres.mpg
      </res>
</item>
```

The length of the Tspec string in CDS is bounded by the UPnP AV specification and for longer Tspec strings indirection through a URI can be used. A potential sample contents of http://1.2.3.4/med-res-tspec is:

```
&lt;TrafficClass&gt;AV&lt;/TrafficClass&gt;
&lt;q:MeanDataRate&gt;15000000&lt;/q:MeanDataRate&gt;
&lt;q:PeakDataRate&gt;17000000&lt;/q:PeakDataRate&gt;
&lt;q:BurstDuration&gt;500&lt;/q:BurstDuration&gt;
&lt;q:BitColor&gt;Red&lt;/q:BitColor&gt;
```

Note that the file must contain escaped XML.

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Annex A
(normative)

Layer 2 Implementation Guidelines

A.1 802.1p and 802.1d, Annex G

Devices which conform to the 802.1p standard should be able to take in the UPnP Traffic Importance Number and convert that into a VLAN tag with the appropriate priority as per IEEE 802.1d, Annex G. Traffic Importance number must not be modified by the implementation and must be used directly.

Processing of received frames should be done in accordance with the 802.1q specification.

A.2 HomePlug

HomePlug defines four priority levels at layer 2. These levels, from highest to lowest priority, are: CA3, CA2, CA1 and CA0. It is recommended that the mapping of the QoS Traffic Importance number to a HomePlug priority be done using IEEE 802.1d Annex G. Based on this the four HomePlug Priorities, the following table of mappings can be applied.

QoS Traffic Importance Number	HomePlug Priority
0	CA1
1	CA0
2	Defined as spare in the 802.1D specification.
3	CA1
4	CA2
5	CA2
6	CA3
7	CA3

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A.3 HPNA 2.0

HPNA 2.0 defines eight priority levels. These are from highest to lowest, 7-0. It is recommended that the mapping of the QoS Traffic Importance number to a HPNA priority be done using IEEE 802.1d Annex G, Using that section and the eight priorities, the following table of mappings can be applied.

QoS Traffic Importance Number	HPNA 2.0 Priority
2	0
1	1
0	*Defined as spare in the 802.1D specification.*
3	3
4	4
5	5
6	6
7	7

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