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SERIES Q: SWITCHING AND SIGNALLING

Signalling requirements for IP-QoS

ITU-T Q-series Recommendations – Supplement 51

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Supplement 51 to ITU-T Q-series Recommendations

Signalling requirements for IP-QoS

Summary

This Supplement specifies IP-QoS signalling requirements for the development of new or enhanced specifications.

It identifies the capabilities for IP-QoS signalling. In addition, it describes the essential features and models for the development of functional entity actions in support of IP-QoS signalling.

Source

Supplement 51 to ITU-T Q-series Recommendations was agreed on 10 December 2004 by ITU-T Study Group 11 (2005-2008).

FOREWORD

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Supplement 51 to ITU-T Q-series Recommendations

Signalling requirements for IP-QoS

1 Scope

This Supplement provides the requirements for signalling information regarding IP-based quality-of-service (QoS) at the interface between the user and the network (UNI), across interfaces between different networks (NNI), including access networks. These requirements and the signalling information elements identified will enable the development of a signalling protocol(s) capable of the request, negotiation and ultimately delivery of known IP QoS classes from UNI to UNI, spanning NNIs as required.

The signalling requirements also address signalling information related to traffic priority and admission control, as these are also central to truly comprehensive QoS.

This Supplement specifies the signalling requirements for control plane and transport control signalling in the support of Quality of Service, without presuming how these requirements may be met. It is based upon the following ITU-T Recs: Y.1221 [9], Y.1291 [8], Y.1540 [6], and Y.1541 [7].

Figure 1 depicts the scope of this Supplement. Note that the figure does not imply that signalling data and user data will necessarily flow on the same links from network to network.

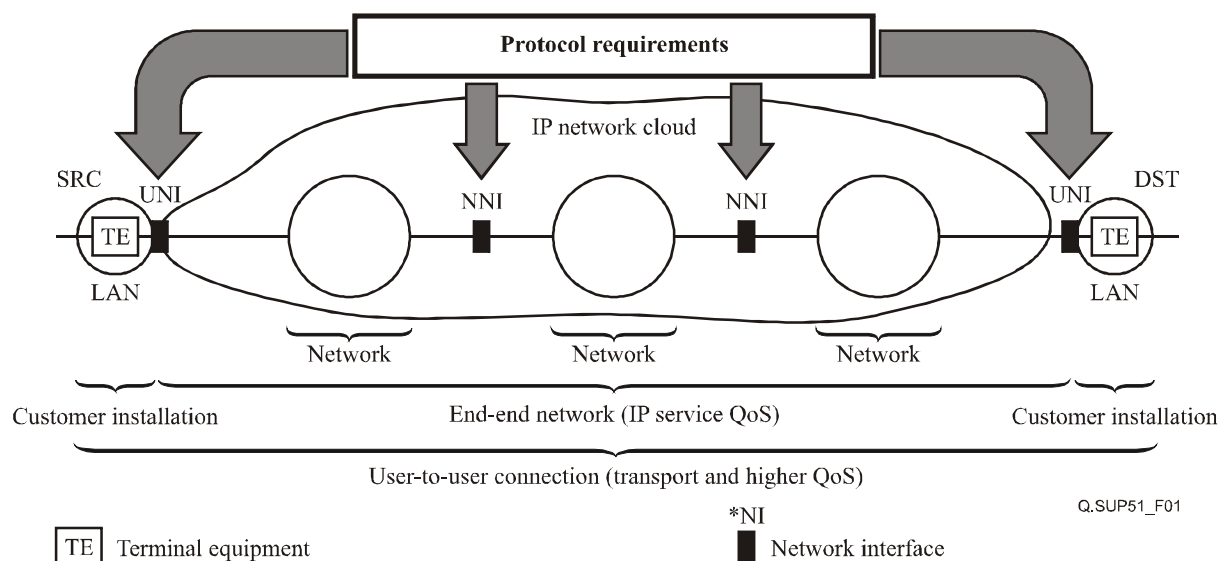


Figure 1 – The Scope of QoS signalling requirements

It is expected that continued study of IP QoS signalling requirements will address interworking/interoperability to allow hybrid signalling solutions.

2 Introduction

Although QoS is by definition (in multiple ISO, ITU-T and other standards) based on the experience of the service user, the mechanisms for achieving differentiated packet treatment are themselves taken all too often as being the same as "real" end-to-end QoS.

To meet specific network performance requirements such as those specified for the QoS classes of ITU-T Rec. Y.1541 [7], a network provider needs to implement services such as those specified in ITU-T Rec. Y.1221 [9].

To implement the transfer capabilities defined in ITU-T Rec. Y.1221 [9], a network needs to provide specific user plane functionality at UNI, NNI, and INI interfaces. A network may be provisioned to meet the performance requirements of ITU-T Rec. Y.1541 [7] either statically or dynamically on a per flow basis using a protocol that meets the requirements specified in this Supplement.

Static network provisioning is typically performed by a network engineering team using a network management system. Static provisioning typically takes into account both overall network performance requirements and performance requirements for individual customers based on traffic contracts between the customer and the network provider.

Dynamic network provisioning at a UNI and/or NNI node allows the ability to dynamically request a traffic contract for an IP flow (as defined in ITU-T Rec. Y.1221 [9]) from a specific source node to one or more destination nodes. In response to the request, the network determines if resources are available to satisfy the request and provision the network.

True QoS goes beyond just the delay and loss that can occur in the transport of IP packets. The requirements include:

- bandwidth/capacity needed by the application, and
- the priority with which such bandwidth will be maintained during congestion and with which it will be restored after various failure events.

As these aspects of QoS can be related to routing, they go beyond the resource management of the packet transport. To make the protocol envisioned by this Supplement comprehensive, requirements on priority and admission controls are also considered.

To achieve the "Hard QoS" guarantee, networks must incorporate the following functions:

- 1) Network resource management with QoS sensitive scalability.
- 2) Intra-domain and inter-domain routing with QoS sensitivity.
- 3) Session admission control with QoS sensitivity.

These functions must be provided whether path-coupled or path-decoupled signalling techniques are utilized within the network.

The requirements in this Supplement are intended to apply to implementations that operate using path-coupled QoS control mode, path-decoupled QoS control mode, or both modes in tandem.

The subject of QoS signalling has generated much interest in the industry. In particular, it is noted that some related work is under way in the IETF NSIS (Next Step in Signalling) Working Group focused on general IP signalling protocols that could be used to achieve different purposes such as QoS and security. The requirements of signalling protocols have been addressed in RFC 3726 [10], in which QoS has been considered as the first-use case. The effort within the IETF is complementary to the contents of this Supplement.

The IP QoS signalling solution needs to be scalable.

3 References

This Technical Report incorporates, by dated or undated reference, provision for referencing material from other publications. These references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this document only when incorporated into it by amendment or revision. For undated references, the latest edition of the publication applies.

- [1] IETF RFC 791 (1981), *Internet Protocol*.
- [2] IETF RFC 2460 (1998), *Internet Protocol, Version 6 (IPv6) Specification*.
- [3] IETF RFC 2474 (1998), *Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers*.
- [4] IETF RFC 768 (1980), *User Datagram Protocol*.
- [5] IETF RFC 793 (1981), *Transmission Control Protocol*.
- [6] ITU-T Recommendation Y.1540 (2002), *Internet protocol data communication service – IP packet transfer and availability performance parameters*.
- [7] ITU-T Recommendation Y.1541 (2002), *Network performance objectives for IP-based services*.
- [8] ITU-T Recommendation Y.1291 (2004), *An architectural framework for support of Quality of Service in packet networks*.
- [9] ITU-T Recommendation Y.1221 (2002), *Traffic control and congestion control in IP-based networks*.
- [10] IETF RFC 3726 (2004), *Requirements for Signalling Protocols*.
- [11] IETF RFC 3260 (2002), *New Terminology and Clarifications for Diffserv*.
- [12] ITU-T Recommendation G.109 (1999), *Definition of categories of speech transmission quality*.
- [13] ITU-T Recommendation G.1010 (2001), *End-user multimedia QoS categories*.
- [14] ITU-T Recommendation P.911 (1998), *Subjective audiovisual quality assessment methods for multimedia applications*.
- [15] ITU-T Recommendation Q.1224 (1997), *Distributed functional plane for intelligent network Capability Set 2*.

4 Definitions

4.1 BCFE: The BCFE is an entity that performs the Resource and Admission Control functions related to QoS requests as well as routing functions.

4.2 IP service endpoint: A functional entity which includes one type of IP signalling endpoint and the user.

4.3 IP signalling endpoint: The termination point of an IP signalling path.

4.4 IP transport packet size: Length of the payload of an IP transport protocol contained in an IP packet.

4.5 network entity: The network element responsible for terminating the IP signalling protocol.

4.6 QoS class: Identifies the category of the information that is received and transmitted in the U-plane.

- 4.7 SeCFE:** The SeCFE (Session Control Functional Entity) is an entity that provides the call/session control function.
- 4.8 SFE:** The SFE (Switching Functional Entity) is an entity that performs stream classification, i.e., QoS guarantee.
- 4.9 SvCFE:** The SvCFE (Service Control Functional Entity) is an entity that provides value-added service functionality.
- 4.10 Terminal Equipment (TE):** A specific implementation of an IP signalling endpoint.
- 4.11 transport connection:** A bidirectional user plane association between two IP service endpoints at the transport layer.
- 4.12 transport sink address:** Contains the IP address and port number, where the sender expects to receive U-plane information.
- 4.13 unidirectional QoS path:** A unidirectional QoS path is a path along which the user data packets flow in the same direction.
- 4.14 user:** An entity served by the IP signalling protocol.

5 Abbreviations

BCFE	Bearer Control Functional Entity
CC	Connection Control
CCI	Connection Control Interface
CN	Core Network
CPN	Customer Premises Network
DiffServ	Differentiated Services
FE	Functional Entity
GW	Gateway
IETF	Internet Engineering Task Force
IN	Intelligent Network
INI	Inter-Network Interface
IP	Internet Protocol
IPDV	IP Packet Delay Variation
IPLR	IP Packet Loss Ratio
IPTD	IP Packet Transfer Delay
MCU	Multipoint Control Unit
MPLS	Multi-Protocol Label Switching
NC	Network Control
NCI	Network Control Interface
NNI	Network-Network Interface
NSIS	Next Step in Signalling
QoS	Quality of Service
SC	Switch Control

SCI	Switching Control Interface
SeCFE	Session Control Functional Entity
SFE	Switching Functional Entity
SvCFE	Service Control Functional Entity
TE	Terminal Equipment
UDP	User Datagram Protocol
UNI	User-Network Interface
VOD	Video On Demand
VoIP	Voice over IP

6 Functional model

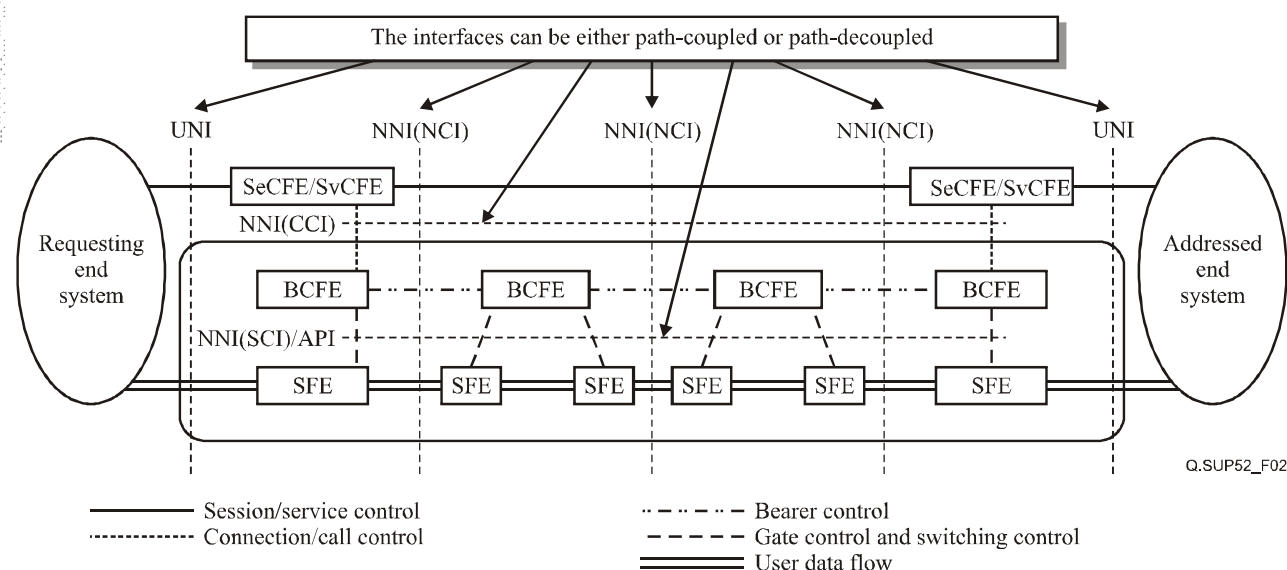


Figure 2 – The functional model of IP QoS signalling requirements

See Appendix I for the detail flows of the interfaces, Appendix II for an instance of functional model of IP QoS signalling requirements, and Appendix III for the description of trust relationships among functional entities. Such a description is considered important for deployment in a multi-operator environment.

Figure 2 depicts the functional model consisting of SeCFE, BCFE, SFE, CCIs and SCIs. It also shows an example of a service-dependent system by illustrating a Session Control FE (SeCFE) and its interface to the service-independent network. Other physical systems that can be used to provide services, such as an intelligent peripheral, could conceptually be included but are not illustrated.

The proposed modular IP QoS components and the interfaces that interconnect them relate to the functional model as follows:

- SeCFE/SvCFE** – An end user interacts with the SeCFE (Session Control Functional Entity)/SvCFE (Service Control Functional Entity) in order to request some service. The SeCFE/SvCFE initiates a QoS request, usually the SeCFE/SvCFE decides the parameters of a communications arrangement (such as bandwidth, quality of service, etc.). If an acceptable set of parameters can be negotiated, the SeCFE uses the services provided by the

BCFE to establish, maintain and disconnect the network resources necessary to provide the negotiated arrangement.

- 1) The SeCFE may appear in one of a number of forms, e.g., as a soft switch, an MCU, a VOD control server, etc. The SeCFE operates at the call/session layer, it performs call/session control, extracts QoS requirements for service connection, and initiates QoS requests to the BCFE of the bearer control plane in transport layer.
- 2) The SvCFE is located within the network domain of the serving node visited by the mobile user. This functional entity provides generic network-based services to all mobile customers. These services have been referred to as default IN services which may be different in each network domain. The SvCFE and the SeCFE associated with the visited serving node are always in the same network domain; therefore, the one-to-one signalling association between these two functional entities is never supported by an inter-domain NNI signalling capability. The network SvCFE performs processing and provides access to data that is specialized for a particular service application. SvCFE extends the generic negotiation and control capabilities provided by SeCFE to support specific end-user services. Within IN terminology, this function is also called the SCF, additional information of which can be found in ITU-T Rec. Q.1224 [15].

- b) **BCFE** – BCFEs (Bearer Control Functional Entities) are responsible for establishing, modifying and releasing the network resources necessary to provide the negotiated arrangement. One connection controller interacts with a peer BCFE to establish and disconnect network facilities on a link-by-link basis. BCFE components provide a generic and flexible connection model that encompasses multimedia and multiparty call requirements. BCFEs control SFEs via an SC Interface.

The BCFE receives a QoS request from the SeCFE/SvCFE, based on a service stream. (For the MPLS case, the BCFE performs service routing. For the non-MPLS case, it performs the identification of the logical path.) After path-analysis, like service routing or the logical-path identification, it delivers the path-analysis results to the SFE.

The BCFE needs certain network topology information and resource status information in order to be able to evaluate QoS requests and generate QoS configuration data, depending on the selected QoS control mode. The nature of this information depends on the transport layer technology, the requirements and protocols for such an interface are out of the scope of this Supplement.

- c) **SFE** – SFEs (Switching Functional Entities) cross-connect a virtual connection at one port with a virtual connection at another port. Via one or more cross-connects at various SFEs located between users, a virtual connection is created between the users. The characteristics of this virtual connection are based on the call parameters negotiated at the SeCFE/SvCFE level and the route is determined by BCFE level. Based on instructions received over the SCI, the SFE, controlled by the BCFE, creates and destroys cross-connects. (For the MPLS case, it also performs MPLS transfer.)
- d) **Connection control interface** – The CCI is the interface between the call/session layer and bearer control plane of transport layer.
- e) **Network control interface** – The NCI is the inter-BCFE interfaces for the cases where it is necessary for two BCFEs to communicate directly.
- f) **Switching control interface** – The SCI is the interface between the bearer control plane of transport layer and transport plane of transport layer.

The functional elements are structured into 2 layers, namely the call and session layer and the transport layer. The transport layer is further subdivided into the bearer control plane and the transport plane. The bearer control plane is composed of the BCFEs. In particular, it does the resource calculation related to service request. (For the MPLS case, it is also responsible for path

6.2 Path-decoupled

The term "path-decoupled" indicates that the signalling forwarding path is different from the user plane path.

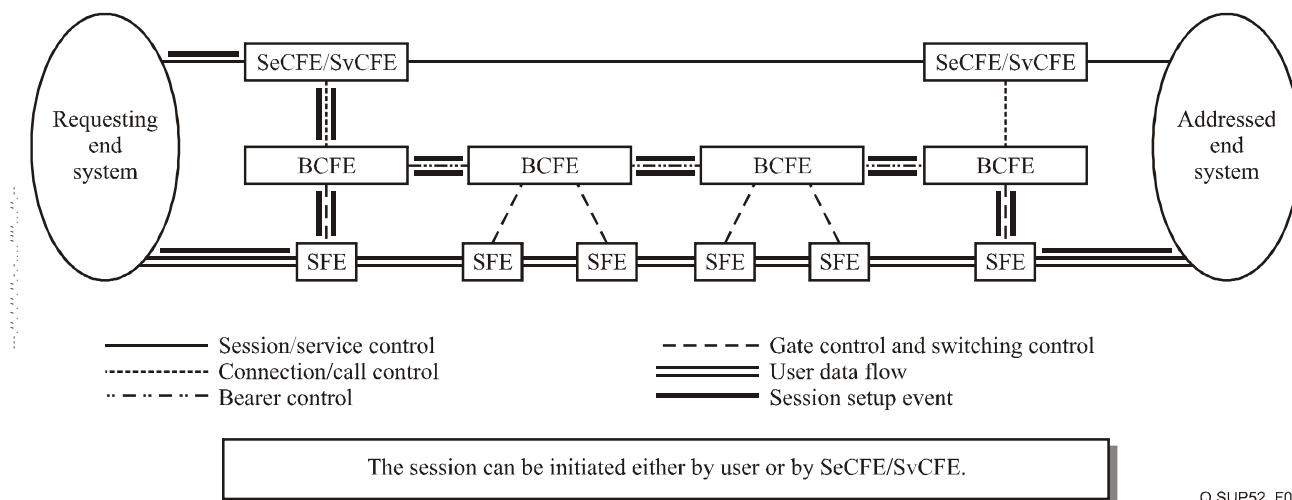


Figure 4 – Path-decoupled QoS control mode

Functionally, the framework is divided into the transport plane of transport layer, bearer control plane of transport layer and call/session control layer. The transport plane of transport layer is divided logically into basic transport plane and logical transport plane.

The basic transport plane means the IP network physical entity that is composed of the SFEs, bearing all types of IP service packets, including voice, fax, video, file transmission and web service.

In the case of the transport plane with the MPLS capability (this case is referred to as "the MPLS case" in what follows), the logical transport plane is planned and configured in advance with MPLS LSP technology.

For the transport plane without the MPLS capability (this case is referred to as "the non-MPLS case" in what follows), the logical transport plane means the networks that are planned and configured logically from the information of the routing topology on the transport plane. Each logical transport plane bears a specific service type or specific-QoS-level IP service packets, such as voice service or expedited forwarding service.

The bearer control plane of the transport layer is composed of the bearer control functional entities. It manages the network resources (bandwidth, priority, transfer delay, transfer delay jitter, etc.) of the transport plane, and controls the resource enablement, allocates the resources and routes for the service request of every QoS service stream, to meet the service stream QoS requirement.

The call/session layer is composed of session control functional entities or service control functional entities that handle the service subscriptions. It determines the service stream required QoS and requests the service stream bearer path from the bearer control plane of transport layer. The SeCFEs/SvCFEs include the soft switch that processes real-time communication call signalling such as VoIP and videotelephony, and the VoD server of the requested of video on demand, etc.

For easy management and stable network, the IP basic network needs to be divided into different management areas, which can be consistent with the division of the routing areas. In each management area, one BCFE uniformly manages the network resources, for the resource enablement control, resource allocation and routing in this management area. The resource managers in different management areas, through their signalling interaction, select a QoS-required path for the subscriber service streams across the management areas for the MPLS case.

In Figure 4 the BCFE serves as a physically independent control and management plane. The building blocks interact primarily through signalling at a per-flow level and on the basis of per-logic transport plane resource management. There is a clear signalling interface between control plane and data plane.

7 Requirements

Authentication of user and network peers is a prerequisite for QoS signalling. Authentication may be accomplished by static extension of the zone of trust, or through an authentication protocol, which is beyond the scope of these requirements.

7.1 User-network signalling

The following requirements apply to QoS signalling between users (or their terminal equipment) and the responsible network entity.

7.1.1 Attributes of a user QoS request

It shall be possible to derive the following service level parameters as part of the process of requesting service:

- 1) QoS class from ITU-T Rec. Y.1541 [7]¹;
- 2) peak rate (Rp);
- 3) peak bucket size (Bp);
- 4) sustainable rate (Rs);
- 5) sustainable bucket size (Bs);
- 6) maximum allowed packet size (M);
- 7) IP DS field as specified in RFC 2474 [3].

It should be possible to derive the following service level parameters as part of the process of requesting service:

- 1) the reliability/priority with which the service is to be sustained, and
- 2) other elements of QoS.

Note that the complete set of classes for reliability/priority is to be defined.

Users must be able to initiate requests for service quality with the following main attributes:

- the network QoS class (e.g., Table 1/Y.1541 [7]);
- the network capacity required, at both the application and network (e.g., ITU-T Rec. Y.1221 [9]) levels;
- the reliability/priority with which the service is to be sustained; and
- other elements of QoS.

Note that the complete set of classes for reliability/priority is to be defined.

¹ The values of IP loss ratio, IP transfer delay, and IP delay variation as specified in ITU-T Rec. Y.1221 [9] may be derived by specifying the QoS class from ITU-T Rec. Y.1541 [7] as a signalling parameter.

Optional attributes include the user application type and quality from among several quality categories, when such categories are available. The type of application may be completely specified from the chosen quality category.

Each of these attributes shall be signalled in independent fields in signalling messages.

Terminal Equipment (TE) should compose the detailed request on the user's behalf, possibly based on configurations set by the user or equipment installer. Many TE have the flexibility to match the user's request for application quality with network QoS classes by selecting parameters such as source coder type and packet size.

7.1.2 Omitting attributes of a user QoS request

Network QoS class, capacity, and reliability/priority are required attributes; others are optional. The network provider may assign default values for omitted attributes.

For example, speech quality categories have been defined in ITU-T Rec. G.109 [12], but there is no comparable standard range of quality categories for Web browsing, financial transactions, or many other applications of networks (each is associated with a limited quality range in ITU-T Rec. G.1010 [13]). ITU-T Rec. P.911 [14] tabulates quality categories for multimedia communication (also known as video/audio/data conferencing) and television applications. Users may simply wish to make requests for capacity, network QoS class, and reliability.

7.1.3 Form of a verifiable user QoS request

The user/TE must make its QoS request in terms the network understands, especially the parameters for network QoS. The network QoS classes and network capacity specifications in the signalling protocol must contain values that are verifiable by users (the classes in ITU-T Rec. Y.1541 [7] meet that requirement). TE may conduct measurements to ensure that the committed performance and capacity levels are achieved by the network(s).

7.1.4 Special case of user QoS request to support voiceband channels

When the user/TE request is for a voiceband channel (to support speech or voiceband modems), the QoS request (or other associated message) should contain the preferred voiceband codec and packet size. Other optional parameters may be included to indicate, for example, the use of silence suppression, the need for network echo cancellation, and alternate codecs/packet sizes.

Many of the capacity attributes will be determined by this codec choice. Also, the network operation benefits from knowledge of the codec when the need for voice transcoding can be identified (and possibly avoided). However, much of the negotiation of application parameters takes place beyond the network's purview.

7.1.5 Flow control for user QoS requests and re-requests

The TE must wait X seconds before re-submitting a request, and may have a maximum of Y simultaneous requests outstanding. Time-outs for re-submission will increase exponentially. The protocol must be "congestion-aware", using failed requests as implicit indications of congestion or using explicit notification of congestion, if available.

7.1.6 Network response to user QoS requests

Network service providers should be able to communicate the following messages and attributes (in the case of user-network interaction):

- 1) An identification code for the request exchange, to be used in this response and all messages that follow (such as user ACK, or release, and also in network-network messages). When used together with other information, such as Src address, each request can be uniquely referenced.
- 2) The simple acknowledgement and acceptance of user/TE requests.

- 3) The performance level expected. The ability to achieve a performance level that is better than an aspect of the QoS class response, if the network operator desires. This indication may be made for a single performance parameter, or for a combination of parameters.
- 4) The ability to reject a request and, at the same time, to offer a modified service level that can be met. The response may modify the request and may include commitments to an alternate QoS Class, a lower capacity, and other indications such as those in item 3.

The processing of each request and determination of acceptance require considerable work on behalf of the network provider/operator. However, these are simple tasks from the signalling point of view, and the rejections with alternatives are illustrated in Appendix V. Networks may wish to indicate a maximum time interval for which the response is valid.

7.1.7 User answer to network QoS response

The final decision to accept or reject an offered service is left to the user/TE. This completes a request-offer-answer exchange.

7.2 QoS signalling at the network-network interface

This clause treats the case where multiple networks cooperate to realize the end-to-end connectivity desired. Beyond the applications considerations mentioned above, network providers/operators primarily deal with network QoS classes, network capacity, and reliability. network-network signalling is the principle way for networks to determine multi-network compliance with QoS classes, since fixed performance allocations are not currently possible on IP networks.

Network-Network signalling shall support the determination of the QoS class offered to the user/TE, by communicating both the network QoS class requested, and the extent to which each specified parameter is already consumed. This implies that each network knows the performance from the entrance node to the (most likely) exit node(s) for the network that has the best opportunity to complete the end-end path. Policies may also determine the next network chosen. The best-next network receives the network-network signalling request.

Networks shall determine if the desired capacity and reliability are available to support the specified network QoS class from entrance to exit node(s).

7.2.1 Attributes of a network QoS request

The attributes of the network's request are:

- the network QoS class (e.g., Table 1/Y.1541 [7]), along with the consumption of individual objectives that are specified by the class;
- the network capacity required, at both the application and network (e.g., ITU-T Rec Y.1221 [9]) levels;
- the interconnecting point(s), where user/TE traffic will leave the requesting network and enter the next network;
- the reliability/priority with which the service is to be sustained; and
- other elements of QoS.

Note that the complete set of classes for reliability/priority is yet to be defined.

Optional attributes include the user application type and the quality category, when such categories are available and meaningful.

Each of these attributes shall be signalled in independent fields in signalling messages.

7.2.2 Omitting attributes of a network QoS request

Network QoS class, capacity, and reliability/priority are required attributes; others are optional.

7.2.3 Performance requirements for QoS requests and re-requests

An important aspect of the requirements for a signalling protocol is the performance requirement associated with that protocol. The most important areas where signalling performance requirements need to be established is the average/maximum latency for the establishment of service and the average/maximum latency for the re-establishment of service in the event of a network failure. The latency requirements described above for the signalling protocol depend on the performance characteristics of the underlying transport network. Because of this, performance requirements for the transport network must be specified along with the latency requirements for the signalling protocol. The combination of these factors leads to the following formal performance requirements for the signalling protocol.

- 1) Networks designed to meet the signalling protocol requirements specified in this clause should be capable of supporting the network performance objectives of QoS class 2 in ITU-T Rec. Y.1541 [7].
- 2) Signalling protocol endpoints that generate signalling messages should be capable of setting the IP DS field of those messages to a value that is associated with the statistical bandwidth transfer capability defined in ITU-T Rec. Y.1221 [9].
- 3) The average delay from the time of a UNI or NNI request for service to the acceptance or rejection of this service request by the network should be <800 ms.
- 4) The maximum delay from the time of a UNI or NNI request for service to the acceptance or rejection of this service request by the network should be <1500 ms.
- 5) The average delay from the time of a network failure to the time of re-establishment of service at any UNI or NNI interface should be <800 ms. (This does not address restoration of failed links.)
- 6) The maximum delay from the time of a network failure to the time of re-establishment of service at any UNI or NNI interface should be <1500 ms.

7.2.4 Response to a network QoS request

Network providers shall be able to respond with the following messages and attributes (in the case of network-network interaction):

- 1) The ability to correlate all responses and subsequent requests to the original request is required. An identification code is one example.
- 2) The simple acknowledgement and acceptance of requests.
- 3) The ability to indicate a performance level that exceeds an aspect of the request/response is required, but the indication to other entities is a network option.
- 4) The terminating network supporting the destination UNI shall offer a modified service level if the original service level cannot be met. The modified service may include commitment to an alternate QoS class, a lower capacity, etc.

It is possible that a chain of network-network QoS requests will encounter a network that does not support the QoS signalling protocol or QoS classes in general. If this network is an essential section of the end-to-end path, then several results are possible. One is to reject the request, but at the same time offer an unspecified class (e.g., class 5 of ITU-T Rec. Y.1541 [7]), possibly with the indication of some additional parameter values.

When making entrance-to-exit performance commitments, only one of the interconnecting links will be included for all networks, except the first network which shall include both the link to the UNI and the link to the NNI (subsequent networks will include the exit link to the next interface, either NNI or UNI).

7.2.5 Accumulating performance for additional requests

Signalling must communicate the consumption of the network (source-UNI to destination-UNI) QoS objectives. The fields used in signalling may take two forms, listed below, but the signalling messages must use one form consistently. See Appendix V for examples based on the Y.1541 [7] network QoS classes.

The forwarded request contains only the achieved values and the requested/achieved class number require signalling fields.

Each network communicates its contribution to the achieved performance level. A complete tabulation of the accumulated performance would allow corrective network actions if the requested class were not achieved.

7.3 QoS Release

Users and networks shall be able to signal when a previously requested network resource is no longer needed.

7.4 Performance

For reasons of signalling performance, the following areas should be addressed:

- a) the number of messages required to establish, maintain and clear QoS requests should be kept to a minimum; and
- b) the format of the IP signalling protocol information should be chosen to minimize message-processing delays at the endpoints.

7.5 Symmetry of information transfer capability

The QoS signalling protocol shall support symmetric QoS requests.

Asymmetric QoS requests are optional. That is, the end-to-end requests may be bidirectional where the information transfer capability in each direction might be different.

7.6 Contention resolution

The QoS signalling protocol shall be able to resolve all contentions with respect to resource allocation and collision.

7.7 Error reporting

The QoS signalling protocol shall include mechanisms for detecting and reporting signalling procedural errors or other failures detected by the TE/network to IP management. Service failures may also be reported to the user.

7.8 Unrecoverable failures

The TE and network entities shall include mechanisms for returning the QoS protocol instance to a stable state after detection of unrecoverable failures.

7.9 Forward and backward compatibility

The QoS signalling protocol shall include a forward compatibility mechanism and backward compatibility rules.

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