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SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

International routing plan

QoS routing support for interworking of QoS service classes across routing technologies

ITU-T Recommendation E.361

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ITU-T Recommendation E.361

QoS routing support for interworking of QoS service classes across routing technologies

Summary

ITU-T Rec. E.360.1, "Framework for QoS routing and related traffic engineering methods for IP-, ATM-, and TDM-based multiservice networks", provides a framework for QoS Service Classes (QSCs), called virtual networks (VNETs) in the E.360.x series. QSCs are defined as aggregations of individual service classes. Instead of having per-class parameters being configured and propagated on each network interface, classes are aggregated into QSCs having common per-QSC parameters (e.g., maximum bandwidth) to satisfy required performance levels. QSCs are known as VNETs in TDM networks, class types in IP/MPLS/DiffServ networks, and QoS classes in ATM networks.

In this Recommendation we identify QoS routing functions and associated parameters, which include:

a) bandwidth allocation/protection, with traffic and QoS parameters;

b) routing priority;

c) queuing priority; and

d) class-of-service identification, with service identity and QSC/VNET parameters.

We propose means of signalling these QoS routing parameters across networks employing different routing technologies, including IP-, ATM-, and TDM-based routing technologies. We propose extensions to signalling protocols such as SIP and RSVP-TE to support signalling of QSCs within and across networks.

Source

ITU-T Recommendation E.361 was prepared by ITU-T Study Group 2 (2001-2004) and approved under the WTSA Resolution 1 procedure on 2 May 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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QoS routing support for interworking of QoS service classes across routing technologies

1 Introduction

Current and future networks are rapidly evolving to carry a multitude of voice/ISDN services and packet data services on Internet Protocol (IP), asynchronous transfer mode (ATM), and time division multiplexing (TDM) networks. QoS routing is an indispensable network function which controls a network's response to traffic demands and other stimuli, such as network failures. QoS routing encompasses traffic management through control of routing functions, which include number/name translation to routing address, connection routing, routing table management, and QoS resource management.

To support the ability to carry all types of telecommunications traffic (voice, data, video, etc.) over a single network, networks are evolving beyond best effort capabilities to provide a variety of performance and reliability options. Transport backbones are incorporating new optical technologies enabling flexible and cost-effective solutions for carrying various grades of telecommunications traffic. It is important for service providers to satisfy customer expectations for end-to-end reliability and QoS, for all types of transactions and services. QoS requirements include performance parameters such as delay, jitter, packet loss, etc, and are related to the type of transaction (e.g., voice, data, video). Reliability on the other hand represents expectations on adequate service availability over a specified period for the desired transaction types, and these expectations are typically negotiated in Service Level Agreements (SLA).

Further, services may have different reliability expectations depending on the type of service. For example, a voice over IP (VoIP) packet stream for emergency services calls would require high priority reliability treatment. Other VoIP services may have lower reliability expectations and hence their network reliability treatment may be less stringent. To satisfy reliability and QoS considerations for all transaction and service types, a service provider needs to ensure that all network protocol layers are equipped to recognize and satisfy the QoS and reliability requirements for the service classes.

ITU-T Rec. E.360.1, "Framework for QoS routing and related traffic engineering methods for IP-, ATM-, and TDM-based multiservice networks," provides a framework for QoS Service Classes (QSCs), called virtual networks (VNETs) in the E.360.x series. QSCs are defined as aggregations of individual service classes. Instead of having per-class parameters being configured and propagated on each network interface, classes are aggregated into QSCs having common per-QSC parameters (e.g., maximum bandwidth) to satisfy required performance levels. There is no maximum or minimum bandwidth requirement to be enforced at the level of individual class in the QSC. QSCs are known as VNETs in TDM networks, class types in IP/MPLS/DiffServ networks, and QoS classes in ATM networks.

In this Recommendation we identify QoS routing functions and associated parameters, which include:

a) bandwidth allocation/protection, with traffic and QoS parameters;

b) routing priority;

c) queuing priority; and

d) class-of-service identification, with service identity and QSC/VNET parameters.

We propose means of signalling these QoS routing parameters across networks employing different routing technologies, including IP-, ATM-, and TDM-based routing technologies. We propose extensions to signalling protocols such as SIP and RSVP-TE to support signalling of QoS routing parameters within and across networks.

Clause 6 summarizes the QoS routing functions and associated parameters. Clause 7 describes proposed means for signalling QoS routing information within protocols such as SIP and RSVP-TE. We discuss necessary signalling and information exchange requirements to enable the QoS routing functions, and to ensure compatibility and inter-working across different types of networks. Clause 8 gives an example of internetwork QoS routing and signalling.

2 Scope

This Recommendation identifies QoS routing functions and associated parameters associated with QSCs, and proposes means of signalling these parameters across networks employing different routing technologies, including IP-, ATM-, and TDM-based routing technologies, as well as the inter-working between these network technologies. Multi-layer QoS routing control functions are identified including:

a) application or 'call' control;

b) vertical control; and

c) bearer control.

We also propose extensions to signalling protocols such as SIP and RSVP-TE to support signalling of QSCs within and across networks. The guidance of this Recommendation applies to QoS routing for individual microflows or for aggregated flows. For QSCs or aggregated flows, this Recommendation applies within networks where an operator can aggregate individual service classes or flows however they wish. However, inter-network aggregation is for further study

3 Definitions

This Recommendation defines the following terms:

3.1 alternate path routing: a routing technique where multiple paths, rather than just the shortest path, between a source node and a destination node are utilized to route traffic, which is used to distribute load among multiple paths in the network.

3.2 blocking: refers to the denial or non-admission of a call or connection-request, based for example on the lack of available resources on a particular link (e.g., link bandwidth or queuing resources).

3.3 call: generic term to describe the establishment, utilization, and release of a connection (bearer path) or data flow.

3.4 call routing: number (or name) translation to routing address(es), perhaps involving use of network servers or intelligent network (IN) databases for service processing.

3.5 circuit switching: denotes the transfer of an individual set of bits within a TDM time-slot over a connection between an input port and an output port within a given circuit-switching node through the circuit-switching fabric (see "switching").

3.6 class of service: characteristics of a service such as described by service identity, virtual network, link capability requirements, QoS and traffic threshold parameters.

3.7 class type: the set of Traffic Trunks crossing a link that is governed by a specific set of bandwidth constraints. Class type is used for the purposes of link bandwidth allocation, constraint based routing, and admission control. A given Traffic Trunk belongs to the same class type on all links.

3.8 connection: bearer path, label switched path, virtual circuit, and/or virtual path established by call routing and connection routing.

3.9 connection admission control: a process by which it is determined whether a link or a node has sufficient resources to satisfy the QoS required for a connection or flow. CAC is typically applied by each node in the path of a connection or flow during set-up to check local resource availability.

3.10 connection routing: connection establishment through selection of one path from path choices governed by the routing table.

3.11 crankback: a technique where a connection or flow set-up is backtracked along the call/connection/flow path up to the first node that can determine an alternative path to the destination node.

3.12 destination node: terminating node within a given network.

3.13 flow: bearer traffic associated with a given connection or connectionless stream having the same originating node, destination node, class of service, and session identification.

3.14 GoS (grade of service): a number of network design variables used to provide a measure of adequacy of a group of resources under specified conditions (e.g., GoS variables may be probability of loss, dial tone delay, etc.).

3.15 GoS standards: parameter values assigned as objectives for GoS variables.

3.16 integrated services: a model which allows for integration of services with various QoS classes, such as key-priority, normal-priority, and best-effort priority services.

3.17 link: a bandwidth transmission medium between nodes that is engineered as a unit.

3.18 logical link: a bandwidth transmission medium of fixed bandwidth (e.g., T1, DS3, OC3, etc.) at the link layer (layer 2) between 2 nodes, established on a path consisting of (possibly several) physical transport links (at layer 1) which are switched, for example, through several optical cross-connect devices.

3.19 node: a network element (switch, router, exchange) providing switching and routing capabilities, or an aggregation of such network elements representing a network.

3.20 multiservice network: a network in which various classes of service share the transmission, switching, queuing, management, and other resources of the network.

3.21 O-D pair: an originating node to destination node pair for a given connection/bandwidth-allocation request.

3.22 originating node: originating node within a given network.

3.23 packet switching: denotes the transfer of an individual packet over a connection between an input port and an output port within a given packet-switching node through the packet-switching fabric (see "switching").

3.24 path: a concatenation of links providing a connection/bandwidth-allocation between an O-D pair.

3.25 physical transport link: a bandwidth transmission medium at the physical layer (layer 1) between 2 nodes, such as on an optical fiber system between terminal equipment used for the transmission of bits or packets (see "transport").

3.26 policy-based routing: network function which involves the application of rules applied to input parameters to derive a routing table and its associated parameters.

3.27 QoS (quality of service): a set of service requirements to be met by the network while transporting a connection or flow. the collective effect of service performance which determine the degree of satisfaction of a *user* of the *service*.

3.28 QoS resource management: network functions which include class-of-service identification, routing table derivation, connection admission, bandwidth allocation, bandwidth protection, bandwidth reservation, priority routing, and priority queuing.

3.29 QoS routing: see "QoS resource management".

3.30 QoS service classes: aggregations of individual service classes with specified QoS requirements of a traffic flow or aggregate. Can be further sub-divided into user-specific and network-related parameters (see also "class type" and "virtual network").

3.31 QoS signalling: a way to communicate QoS routing information between hosts, end systems and network devices, etc. May include request and response messages to facilitate negotiation/re-negotiation.

3.32 resource: something of value in a network infrastructure to which rules or policy criteria are first applied before access is granted. Examples of resources include the buffers in a router and bandwidth on an interface.

3.33 resource allocation: part of a resource that has been dedicated for the use of a particular traffic type for a period of time through the application of policies.

3.34 route: a set of paths connecting the same originating node-destination node pair.

3.35 routing: the process of determination, establishment, and use of routing tables to select paths between an input port at the ingress network edge and output port at the egress network edge. includes the process of performing both call routing and connection routing (see "call routing" and "connection routing").

3.36 routing table: describes the path choices and selection rules to select one path out of the route for a connection/bandwidth-allocation request.

3.37 routing table management: use of information, such as topology update, status information, or routing recommendations, to design and generate the routing table.

3.38 switching: denotes connection of an input port to an output port within a given node through the switching fabric.

3.39 traffic engineering: encompasses traffic management, capacity management, traffic measurement and modeling, network modelling, and performance analysis.

3.40 traffic engineering methods: network functions which support traffic engineering and include call routing, connection routing, QoS resource management, routing table management, and capacity management.

3.41 traffic stream: a class of connection requests with the same traffic characteristics.

3.42 traffic trunk: an aggregation of traffic flows of the same class which are routed on the same path (see "logical link").

3.43 transport: refers to the transmission of bits or packets on the physical layer (layer 1) between two nodes, such as on an optical fiber system between terminal equipment (note that this definition is distinct from the IP-protocol terminology of transport as end-to-end connectivity at layer 4, such as with the Transport Control Protocol (TCP)).

3.44 via node: an intermediate node in a path within a given network.

3.45 virtual network: the set of traffic flows of the same class crossing a link that is governed by a specific set of bandwidth constraints. VNET is used for the purposes of link bandwidth allocation, constraint-based routing, and admission control. A given flow belongs to the same VNET on all links.

4 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

– ITU-T Recommendation E.170 (1992), *Traffic routing*.

– ITU-T Recommendation E.350 (2000), *Dynamic routing interworking*.

– ITU-T Recommendation E.351 (2000), *Routing of multimedia connections across TDM-, ATM-, and IP-based networks*.

– ITU-T Recommendation E.352 (2000), *Routing guidelines for efficient routing methods*.

– ITU-T Recommendation E.353 (2001), *Routing of calls when using international network routing addresses*.

– ITU-T Recommendation E.360.1 (2002), *Framework for QoS routing and related traffic engineering methods for IP-, ATM-, and TDM-based multiservice networks*.

– ITU-T Recommendation E.360.2 (2002), *QoS routing and related traffic engineering methods – Call routing and connection routing methods*

– ITU-T Recommendation E.360.3 (2002), *QoS routing and related traffic engineering methods – QoS resource management methods*.

– ITU-T Recommendation E.360.4 (2002), *QoS routing and related traffic engineering methods – Routing table management methods and requirements*.

– ITU-T Recommendation E.360.5 (2002), *QoS routing and related traffic engineering methods – Transport routing methods*.

– ITU-T Recommendation E.360.6 (2002), *QoS routing and related traffic engineering methods – Capacity management methods*.

– ITU-T Recommendation E.360.7 (2002), *QoS routing and related traffic engineering methods – Traffic engineering operational requirements*.

– ITU-T Recommendation I.356 (2000), *B-ISDN ATM layer cell transfer performance*.

– ITU-T Recommendation Y.1541 (2002), *Network performance objectives for IP-based services*.

5 Abbreviations

This Recommendation uses the following abbreviations:

ABR	Available Bit Rate
ADR	Address
AESA	ATM End System Address
AINI	ATM Inter-Network Interface
ALB	Available Link Bandwidth
ARR	Automatic Rerouting
AS	Autonomous System
ATM	Asynchronous Transfer Mode
B	Busy
BBP	Bandwidth Broker Processor
BGP	Border Gateway Protocol
BICC	Bearer Independent Call Control
B-ISDN	Broadband-Integrated Services Digital Network
BNA	Bandwidth Not Available
BW	Bandwidth
CAC	Call (or Connection) Admission Control
CBK	Crankback
CBR	Constant Bit Rate
CCS	Common Channel Signalling
CIC	Call Identification Code
COPS	Common Open Policy Service
CRLDP	Constraint-based Routing Label Distribution Protocol
CRLSP	Constraint-based Routing Label Switched Path
DCC	Data Country Code
DIFFSERV	Differentiated Services
DN	Destination Node
DSCP	Differentiated Services Code Point
DTL	Designated Transit List
ER	Explicit Route
FR	Fixed Routing
GCAC	Generic Call Admission Control
GOS	Grade of Service
IAM	Initial Address Message
IE	Information Element
IETF	Internet Engineering Task Force

IP	Internet Protocol
LC	Link Capability
LDP	Label Distribution Protocol
LSA	Link State Advertisement
LSP	Label Switched Path
MEGACO	Media Gateway Control
MOD	Modify
MPLS	Multi-Protocol Label Switching
NANP	North American Numbering Plan
NSAP	Network Service Access Point
ON	Originating Node
OSPF	Open Shortest Path First
PAR	Parameters
PHB	Per-Hop Behavior
PNNI	Private Network-to-Network Interface
PSTN	Public Switched Telephone Network
PTSE	PNNI Topology State Elements
QoS	Quality of Service
QSC	QoS Service Class
RES	Reservation
RQE	Routing Query Element
RRE	Routing Recommendation Element
RSE	Routing State Element
RSVP	Resource Reservation Protocol
SCP	Service Control Point
SDR	State-Dependent Routing
SI	Service Identity
SIP	Session Initiation Protocol
SS7	Signalling System No. 7
SVC	Switched Virtual Circuit
SVP	Switched Virtual Path
TDR	Time-Dependent Routing
ToS	Type of Service
TRAF	Traffic
TSE	Topology State Element
UBR	Unassigned Bit Rate
UNI	User-Network Interface

VBR	Variable Bit Rate
VC	Virtual Circuit
VCI	Virtual Circuit Identifier
VN	Via Node
VNET	Virtual Network
VP	Virtual Path
VPI	Virtual Path Identifier

6 QoS routing functions and parameters associated with QoS service classes

In this Recommendation we identify QoS routing functions and associated parameters, which include:

1) bandwidth allocation/protection, with traffic and QoS parameters;
2) routing priority;
3) queuing priority; and
4) class-of-service identification, with service identity and QSC/VNET parameters.

Bandwidth allocation and protection includes connection admission and bandwidth reservation. Typically, the connection admission control for each link in the path is performed based on the status of the link. The originating node (ON) may select any path for which the first link is allowed according to QoS resource management criteria. If a subsequent link is not allowed, then a release with crankback/bandwidth-not-available is used to return to the ON and select an alternate path. QSC/VNET bandwidth is managed to meet the overall bandwidth requirements of QSC service needs. Individual flows are allocated bandwidth within QSC/VNETs accordingly, as bandwidth is available. Bandwidth reservation gives preference to the preferred traffic by allowing it to seize any idle bandwidth in a link, while allowing the non-preferred traffic to only seize bandwidth if there is a minimum level of idle bandwidth available, where the minimum-bandwidth threshold is called the reservation level. Bandwidth reservation protection is robust to traffic variations, provides dynamic protection of particular streams of traffic, and is a crucial technique to prevent "instability", which can severely reduce throughput in periods of congestion.

Priority routing can give preference to admit and/or restore higher priority connections ahead of lower priority connections. A high-priority service can be admitted in preference over a normal-priority service by reserving the last-available, minimum-level of bandwidth (called the "reserved bandwidth") for high-priority service admissions vs. normal-priority service admissions. That is, the higher priority connection gets the reserved bandwidth when that is all the bandwidth left. This concept is widely used in practice today for voice and data services (e.g., "800 gold service", "emergency communication service"). Restoration priority can assign a priority to traffic streams for restoration. As in the case for connection admission, certain services may require higher restoration priority over others. Bandwidth allocation/protection and priority routing reflect reliability expectations/objectives such as loss probability, time-to-restore, and extent of restoration. Draft ITU-T Rec. [Y.qosar] is recommending four priority levels for connection admission control, with the highest 'critical' priority being reserved for emergency communications traffic, and three priority levels for restoration.

Priority queuing considers packet level objectives and performance expectations such as delay, loss, and delay variation. ITU-T Rec. Y.1541 groups services into six QoS classes defined according to the desired QoS performance objectives: Classes 0 and 1, which generally correspond to the DiffServ EF PHB, support interactive real-time applications; Classes 2, 3, and 4, which generally correspond to the DiffServ AFxy PHB Group, support non-interactive applications; Class 5, which generally corresponds to the DiffServ best-effort PHB, has all the QoS parameters unspecified. There are three types of DiffServ PHBs:

a) default/best effort, no special treatment is accorded to the packet;

b) expedited forwarding (EF), packets requiring low loss and low delay;

c) assured forwarding (AF), offers four AF classes *x* with one of three possible drop precedence values *y* per AF class represented by the notation AF*xy*.

Class-of-service identification entails identifying class-of-service parameters, which include:

a) service identity (SI);

b) virtual network (VNET/QSC);

c) link capability (LC).

The SI describes the actual service associated with the connection. The VNET/QSC describes the bandwidth allocation and routing table parameters to be used by the connection. The LC describes the link hardware capabilities such as fiber, radio, satellite, and digital circuit multiplexing equipment, that the connection should require, prefer, or avoid. Determination of class-of-service begins with translation of the end-user name at the ON to determine the routing address of the destination node, and then the use of other data derived from call information, such as signalling message information and network control point routing information, to derive the class-of-service. VNET/QSCs are known as VNETs in TDM networks, class types in IP/MPLS networks, and QoS classes in ATM networks.

7 Signalling of QoS routing information within and across networks

QoS control includes the following functions:

a) application or 'call' control (SIP/SDP, H.323, etc.);

b) vertical control (H.248/MEGACO, etc.); and

c) bearer control (MPLS, RSVP/RSVP-TE, DiffServ, COPS, etc.).

These are now discussed.

7.1 Application/Call control

End-to-end QoS control is negotiated/communicated end-to-end at the call control level. The idea is that call control protocols are enhanced with a generic end-to-end QoS service control mechanism to negotiate the associated QoS routing parameters (bandwidth, Y.1541 QoS class, etc.). Such an end-to-end QoS control mechanism is defined independent of the underlying technology (IP, ATM, etc.) and operates across network domains. These QoS routing parameters need to be mapped to specific IP, ATM, and TDM VNET/QSCs (class type, QoS class, VNET, respectively) and these mappings should be made available to the appropriate control elements. Such enhancements are applicable to call-control protocols like SIP/SDP, H.323, etc.

7.2 Vertical control

QoS routing control is also negotiated/communicated at the vertical control level. The proposed signalling requirements include the vertical interface. The idea is that vertical control protocols are enhanced to negotiate/communicate the QoS parameters (bandwidth, Y.1541 QoS class, etc.) in the bearer network based on H.248/MEGACO extensions. These QoS parameters are defined independent of the underlying technology (IP, ATM, etc.) of the bearer network. The vertical interface then maps the application QoS routing parameters into the bearer QoS routing parameters.

7.3 Bearer control

Bearer network QoS is negotiated/communicated at the bearer control level. IP bearer control protocols are enhanced with a mechanism to negotiate the network QoS by using QoS routing parameters and transfer capabilities. Bearer network QoS is negotiated/communicated at the bearer level, i.e., as part of the protocols associated with the bearers in the core network. QoS routing and transfer capabilities are used to enhance existing IP mechanisms like MPLS, RSVP/RSVP-TE, DiffServ, COPS, etc.

Note that the guidance in this Recommendation applies to QoS routing for individual microflows or for aggregated flows. For QSCs and aggregated flows, this Recommendation applies within networks where an operator can aggregate individual service classes or flows however they wish. However inter-network aggregation is for further study. The ITU-T Rec. E.360.x series analyzes QoS routing for both microflow and aggregated options in detail: the microflow routing option has some benefit relative to aggregated QoS routing, although the differences are not large.

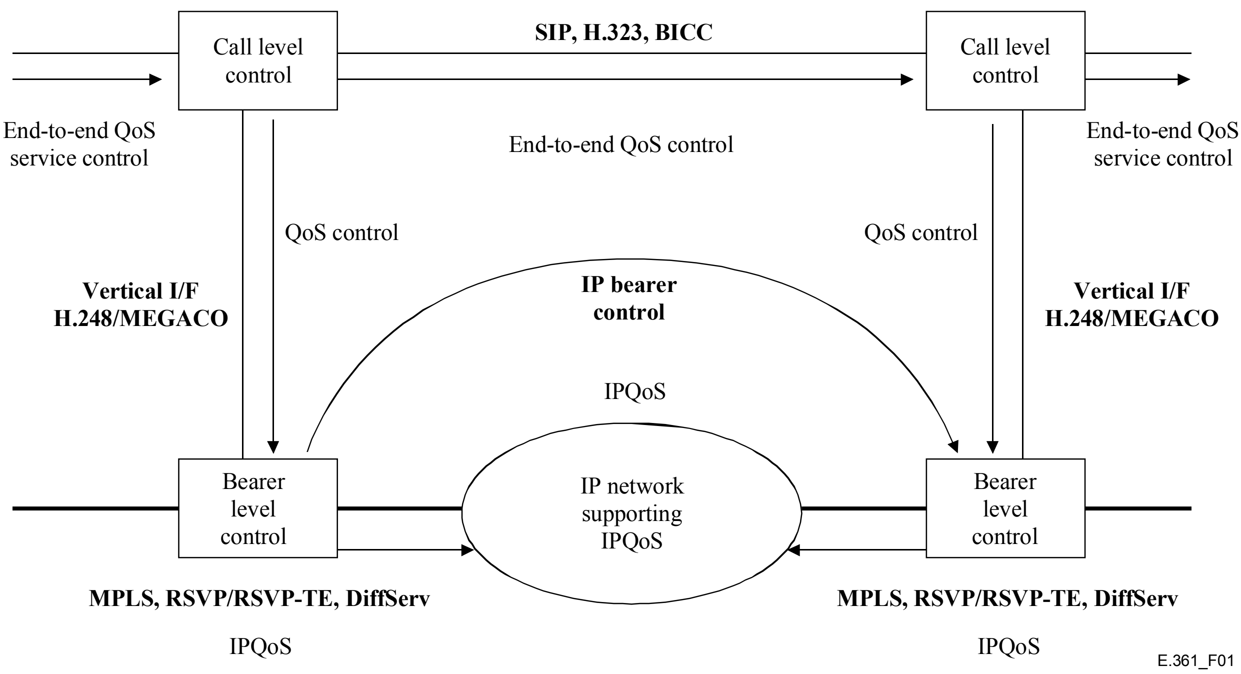

Figure 1/E.361 – Framework for end-to-end QoS Control in IP-based networks

7.4 Proposed signalling protocol extensions

This Recommendation proposes standard signalling protocols for communicating the QoS requirements among the major entities. Table 1 summarizes the required signalling and information exchange parameters supported within each routing technology which are required to be supported across network types. Table 1 identifies:

1) required information-exchange parameters, shown in non-bold type, to support the QoS routing functions and parameters; and
2) required standards, shown in bold type, to support the information-exchange parameters.

Table 1/E.361 – Required signalling and information-exchange parameters to support QoS routing functions and parameters (Required standards in bold)

QoS routing function	Network technology (Standards source)			
	PSTN/TDM-based (ITU-T standards)	ATM-based (ATMF standards)	IP-based (IETF standards)	Harmonized standards
BW Allocation and Protection	Y.1541 QoS Class/ QoS-PAR, TRAF-PAR, RES, MOD **E.351, E.360, clause 7.4**	Y.1541 QoS Class/ QoS-PAR, TRAF-PAR, RES, MOD **UNI, PNNI, AINI, BW-MODIFY**	Y.1541 QoS Class/ QoS-PAR, TRAF-PAR, RES, MOD **OSPF, BGP, RSVP/RSVP-TE**	Y.1541 QoS Class/QoS-PAR, TRAF-PAR, RES, MOD, **clause 7.4**
Priority Routing	CAC-PRTY REST-PRTY **E.351, E.360, clause 7.4**	CAC-PRTY REST-PRTY **UNI, PNNI, AINI, BW-MODIFY**	CAC-PRTY REST-PRTY **OSPF, BGP, RSVP/ RSVP-TE**	CAC-PRTY REST-PRTY, **clause 7.4**
Priority Queuing	N/A	DIFFSERV **UNI, PNNI, AINI, BW-MODIFY, I.356**	DIFFSERV **DIFFSERV, OSPF, BGP, RSVP/RSVP-TE, Y.1541**	DIFFSERV, **clause 7.4**
Class-of-Service	SI, VNET, LC, **clause 7.4**	SI, QoS Class, LC, **clause 7.4**	SI, Class Type, LC, **clause 7.4**	SI, QSC, LC, **clause 7.4**

These QoS routing information-exchange parameters are required:

1) QoS parameters (QoS-PAR): The QoS-PAR include QoS thresholds such as transfer delay, delay variation, and packet loss. Preferably, the Y.1541 QoS class is specified requiring the QoS performance objectives specified for the selected class. Alternatively, the QoS-PAR performance thresholds are individually specified. The QoS-PAR parameters are used by each VN to compare the link QoS performance to the requested QoS threshold to determine if the connection/bandwidth-allocation request is admitted or blocked on that link.

2) Traffic parameters (TRAF-PAR): The TRAF-PAR include traffic parameters such as average bit rate, maximum bit rate, and minimum bit rate. The TRAF-PAR parameters are used by each VN to compare the link traffic characteristics to the requested TRAF-PAR thresholds to determine if the connection/bandwidth-allocation request is admitted or blocked on that link.

3) Reservation (RES) parameter: The RES parameter is used by each VN to compare the load state on the link to the allowed RES to determine if the connection/bandwidth-allocation request is admitted or blocked on that link.

4) Modify (MOD) parameter: The MOD parameter is used by each VN to compare the requested modified traffic parameters on an existing SVP/CRLSP to determine if the modification request is admitted or blocked on that link.

5) Connection admission control priority (CAC-PRTY) parameter: The CAC-PRTY parameter is used by each VN to determine the priority of the connection/bandwidth-allocation request being admitted on that link.

6) Restoration priority (REST-PRTY) parameter: The REST-PRTY parameter is used by each VN to determine the priority of the connection/bandwidth-allocation request being restored on a given VP/LSP and/or transport link.

7) Differentiated services (DIFFSERV) parameter: The DIFFSERV parameter is used in ATM-based and IP-based networks to support priority queuing. The DIFFSERV parameter is used at the queues associated with each link to designate the relative priority and management policy for each queue.

8) Service Identity (SI) parameter: The SI parameter describes the actual service associated with the call.

9) Virtual Network (VNET)/QoS Service Class (QSC) parameter: The VNET/QSC parameter describes the bandwidth allocation and routing table parameters to be used by the call.

10) Link Capability (LC) parameter: The LC parameter describes the link hardware capabilities such as fiber, radio, satellite, and digital circuit multiplexing equipment (DCME), that the call should require, prefer, or avoid.

It is required that the QoS-PAR, TRAF-PAR, RES, MOD, CAC-PRTY, REST-PRTY, DIFFSERV, SI, QSC, and LC parameters be included (as appropriate) in the initial address message (IAM) for TDM-based networks, the SVC/SVP SETUP IE and SVP MODIFY REQUEST IE for ATM-based networks, and MPLS RSVP/RSVP-TE IE for IP-based networks. Note that specifying the QSC parameter implicitly defines the CAC priority, RESToration priority, and DIFFSERV parameters (as per Table 1); however, the individual parameters can be included to override the default values if needed.

These parameters are used to control the routing, bandwidth allocation, and routing/queuing priorities.

As shown in Table 1, it is required that the QoS-PAR and TRAF-PAR elements be developed within TDM-based networks to support bandwidth allocation and protection, which will be compatible with the QoS-PAR and TRAF-PAR elements in ATM-based and IP-based networks. In addition, it is required that the RES element be developed within TDM-based networks, which will be compatible with the RES element in ATM-based and IP-based networks. It is required that the DIFFSERV element should be developed in ATM-based and IP-based networks to support priority queuing. It is required that the CAC-PRTY, REST-PRTY, SI, QSC, and LC elements should be developed in TDM-based, ATM-based, and IP-based networks to support class-of-service signalling. It is required that QoS-resource-management methods be developed supported by these parameters for TDM-based networks.

Required extensions to IP signalling protocols such as SIP, RSVP-TE, and COPS are as follows: Traffic parameters, CAC priority, restoration priority, DiffServ/QoS PHB, SI/VNET/LC, etc. information can be conveyed in connection setup using existing MPLS DiffServ extensions [DIFF-MPLS, MPLS-DS-TE] and setup priority parameters already being specified [RSVP, RSVP-TE]. Conveying the restoration priority information could be done in the restoration parameter being defined in GMPLS.

8 Example of internetwork QoS routing and signalling

A network consisting of various subnetworks using different routing protocols is considered in this clause. As illustrated in Figure 2, consider a network with four subnetworks denoted as networks A, B, C, and D, where each network uses a different routing protocol. In this example, network A is an ATM-based network which uses PNNI path selection, network B is a TDM-based network which uses centralized periodic SDR (state-dependent routing) path selection, network C is an IP-based network which uses MPLS path selection, and network D is a TDM-based network which uses TDR (time-dependent routing) path selection. Internetwork E is defined by the shaded nodes in Figure 2 and is a virtual network where the interworking between networks A, B, C, and D is actually taking place.

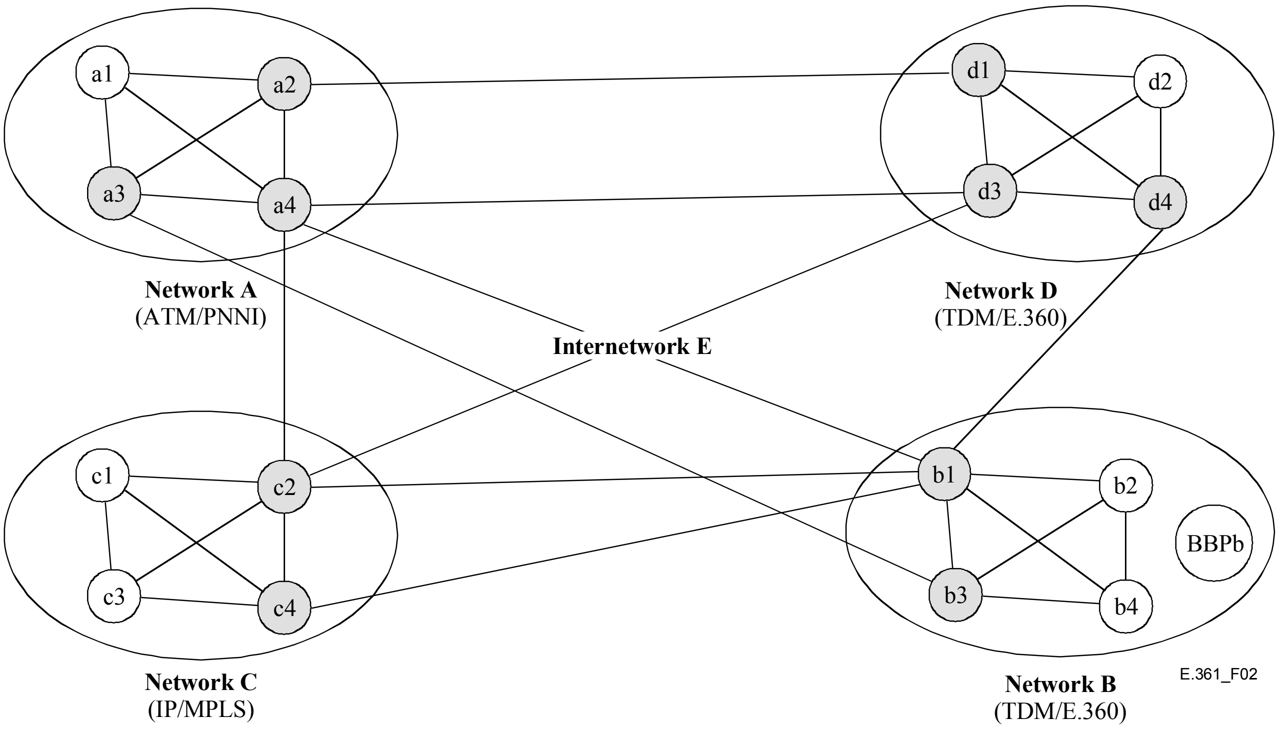

Figure 2/E.361 – Example of an internetwork QoS routing and signalling scenario

The set of shaded nodes is internetwork E for routing of connection/bandwidth-allocation requests between networks A, B, C, and D.

Consider a connection/bandwidth-allocation request from node a1 in network A to node b4 in network B. Node a1 first routes the connection/bandwidth-allocation request to either node a3 or a4 in network A. In so doing node a1 and node a3 put the QoS-PAR, TRAF-PAR, CAC-PRTY, REST-PRTY, and SI/VNET/LC parameters in the connection/bandwidth-allocation request connection-setup IE.

Node a4 now proceeds to route the connection/bandwidth-allocation request to node b1 in subnetwork B using EDR path selection. In that regard node a4 first tries to route the connection/bandwidth-allocation request on the direct link a4-b1, and assuming that link a4-b1 bandwidth is unavailable then selects the current successful path a4-c2-b1 and routes the connection/bandwidth-allocation request to node b1 via node c2. In so doing node a4 and node c2 put the QoS-PAR, TRAF-PAR, CAC-PRTY, REST-PRTY, and SI/VNET/LC parameters in the connection/bandwidth-allocation request connection-setup IE.

If node c2 finds that link c2-b1 does not have sufficient available bandwidth, it returns control of the connection/bandwidth-allocation request to node a4. If now node a4 finds that link d4-b1 has sufficient idle bandwidth capacity, then node a4 could next try path a4-d3-d4-b1 to node b1. In that case node a4 routes the connection/bandwidth-allocation request to node d3 on link a4-d3, and node d3 is sent the QoS-PAR, TRAF-PAR, CAC-PRTY, REST-PRTY, and SI/VNET/LC parameters in the connection/bandwidth-allocation request connection-setup IE. In that case node d3 tries to seize idle bandwidth on link d3-d4, and assuming that there is sufficient idle bandwidth routes the connection/bandwidth-allocation request to node d4 with the QoS-PAR, TRAF-PAR, CAC-PRTY, REST-PRTY, and SI/VNET/LC parameters in the connection/bandwidth-allocation request connection-setup IE. Node d4 then routes the connection/bandwidth-allocation request on link d4-b1 to node b1, which has already been determined to have sufficient idle bandwidth capacity. If on the other hand there is insufficient idle d4-b1 bandwidth available, then node d3 returns control of the call to node a4. At that point node a4 may try another multilink path, such as a4-a3-b3-b1, using the same procedure as for the a4-d3-d4-b1 path.

Node b1 now proceeds to route the connection/bandwidth-allocation request to node b4 in network B using centralized periodic SDR path selection. In that regard node b1 first tries to route the connection/bandwidth-allocation request on the direct link b1-b4, and assuming that link b1-b4 bandwidth is unavailable then selects a two-link path b1-b2-b4 which is the currently recommended alternate path from the BBPb (bandwidth broker processor) for network B. BBPb bases its alternate routing recommendations on periodic (say every 10 seconds) link and traffic status information received from each node in network B. Based on the status information, BBPb then selects the two-link path b1-b2-b4 and sends this alternate path recommendation to node b1 on a periodic basis (say every 10 seconds). Node b1 then routes the connection/bandwidth-allocation request to node b4 via node b2. In so doing node b1 and node b2 put the QoS-PAR, TRAF-PAR, CAC-PRTY, REST PRTY, and SI/VNET/LC parameters in the connection/bandwidth-allocation request connection-setup IE.

A connection/bandwidth-allocation request from node b4 in network B to node a1 in network A would mostly be the same as the connection/bandwidth-allocation request from a1 to b4, except with all the above steps in reverse order. The difference would be in routing the connection/bandwidth-allocation request from node b1 in network B to node a4 in network A. In this case, the b1 to a4 connection/bandwidth-allocation request would use centralized periodic SDR path selection, since node b1 is in network B, which uses centralized periodic SDR. In that regard node b1 first tries to route the connection/bandwidth-allocation request on the direct link b1-a4, and assuming that link b1-a4 bandwidth is unavailable then selects a two-link path b1-c2-a4 which is the currently recommended alternate path identified from the BBPb for virtual network E. BBPb bases its alternate routing recommendations on periodic (say every 10 seconds) link and traffic status information received from each node in virtual subnetwork E. Based on the status information, BBPb then selects the two-link path b1-c2-a4 and sends this alternate path recommendation in the RRE parameter to node b1 on a periodic basis (say every 10 seconds). Node b1 then routes the connection/bandwidth-allocation request to node a4 via VN c2. In so doing node b1 and node c2 put the QoS-PAR, TRAF-PAR, CAC-PRTY, REST-PRTY, and SI/VNET/LC parameters in the connection/bandwidth-allocation request connection-setup IE.

If node c2 finds that link c2-a4 does not have sufficient available bandwidth, it returns control of the connection/bandwidth-allocation request to node b1. If now node b1 finds that path b1-d4-d3-a4 has sufficient idle bandwidth capacity, then node b1 could next try path b1-d4-d3-a4 to node a4. In that case node b1 routes the connection/bandwidth-allocation request to node d4 on link b1-d4, and node d4 is sent the QoS-PAR, TRAF-PAR, CAC-PRTY, REST-PRTY, and SI/VNET/LC parameters in the connection/bandwidth-allocation request connection-setup IE. In that case node d4 tries to seize idle bandwidth on link d4-d3, and assuming that there is sufficient idle bandwidth routes the connection/bandwidth-allocation request to node d3 with the QoS-PAR, TRAF-PAR, CAC-PRTY, REST-PRTY, and SI/VNET/LC parameters in the connection/bandwidth-allocation request connection-setup IE. Node d3 then routes the connection/bandwidth-allocation request on link d3-a4 to node a4, which is expected based on status information to have sufficient idle bandwidth capacity. If on the other hand there is insufficient idle d3-a4 bandwidth available, then node d3 returns control of the call to node b1. At that point node b1 may try another multilink path, such as b1-b3-a3-a4, using the same procedure as for the b1-d4-d3-a4 path.

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