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## E.360.3

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

International routing plan

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**QoS routing and related traffic engineering  
methods – QoS resource management methods**

ITU-T Recommendation E.360.3

ITU-T E-SERIES RECOMMENDATIONS  
**OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS**

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# ITU-T Recommendation E.360.3

## QoS routing and related traffic engineering methods – QoS resource management methods

### Summary

The E.360.x series of Recommendations describes, analyzes, and recommends methods which control a network's response to traffic demands and other stimuli, such as link failures or node failures. The functions discussed and recommendations made related to traffic engineering (TE) are consistent with the definition given in the Framework document of the Traffic Engineering Working Group (TEWG) within the Internet Engineering Task Force (IETF):

Internet Traffic Engineering is concerned with the performance optimization of operational networks. It encompasses the measurement, modelling, characterization, and control of Internet traffic, and the application of techniques to achieve specific performance objectives, including the reliable and expeditious movement of traffic through the network, the efficient utilization of network resources, and the planning of network capacity.

The methods addressed in the E.360.x series include call and connection routing, QoS resource management, routing table management, dynamic transport routing, capacity management, and operational requirements. Some of the methods proposed herein are also addressed in or are closely related to those proposed in ITU-T Recs E.170 to E.179 and E.350 to E.353 for routing, E.410 to E.419 for network management and E.490 to E.780 for other traffic engineering issues.

The recommended methods are meant to apply to IP-based, ATM-based, and TDM-based networks, as well as the interworking between these network technologies. Essentially all of the methods recommended are already widely applied in operational networks worldwide, particularly in PSTN networks employing TDM-based technology. However, these methods are shown to be extensible to packet-based technologies, that is, to IP-based and ATM-based technologies, and it is important that networks which evolve to employ these packet technologies have a sound foundation of methods to apply. Hence, it is the intent that the methods recommended in this series of Recommendations be used as a basis for requirements for specific methods, and, as needed, for protocol development in IP-based, ATM-based, and TDM-based networks to implement the methods.

The methods encompassed in this Recommendation include traffic management through control of routing functions, which include QoS resource management. Results of analysis models are presented which illustrate the tradeoffs between various approaches. Based on the results of these studies as well as established practice and experience, methods are recommended for consideration in network evolution to IP-based, ATM-based, and/or TDM-based technologies.

### Source

ITU-T Recommendation E.360.3 was prepared by ITU-T Study Group 2 (2001-2004) and approved under the WTSA Resolution 1 procedure on 16 May 2002.

## 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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## Introduction

QoS resource management (sometimes called QoS routing) functions include class-of-service identification, routing table derivation, connection admission, bandwidth allocation, bandwidth protection, bandwidth reservation, priority routing, priority queuing, and other related resource management functions. A broad classification of these functions is as follows:

- 1) connection-level controls: provide the required connection-level GoS objectives in an economical way;
- 2) packet-level controls: ensure the required packet-level GoS objectives.

Connection-level controls are discussed in clauses 5 to 8, and packet level controls are discussed in clause 9.

QoS resource management methods have been applied successfully in TDM-based networks [A98], and are being extended to IP-based and ATM-based networks. In an illustrative QoS resource management method, bandwidth is allocated in discrete changes to each of several virtual networks (VNETs), which are each assigned a priority corresponding to either high-priority key services, normal-priority services, or best-effort low-priority services. Examples of services within these VNET categories include:

- high-priority key services such as defense voice communication;
- normal-priority services such as constant rate, interactive, delay-sensitive voice; variable rate, interactive, delay-sensitive IP-telephony; and variable rate, non-interactive, non-delay-sensitive WWW file transfer; and
- low-priority best-effort services such as variable rate, non-interactive, non-delay-sensitive voice mail, email, and file transfer.

Bandwidth changes in VNET bandwidth capacity can be determined by edge nodes on a per-flow (per-connection) basis, or based on an overall aggregated bandwidth demand for VNET capacity (not on a per-connection demand basis). In the latter case of per-VNET bandwidth allocation, based on the aggregated bandwidth demand, edge nodes make periodic discrete changes in bandwidth allocation, that is, either increase or decrease bandwidth, such as on the constraint-based routing label switched paths (CRLSPs) constituting the VNET bandwidth capacity.

In the illustrative QoS resource management method, which we assume is MPLS-based, the bandwidth allocation control for each VNET CRLSP is based on estimated bandwidth needs, bandwidth use, and status of links in the CRLSP. The edge node, or originating node (ON), determines when VNET bandwidth needs to be increased or decreased on a CRLSP, and uses an illustrative MPLS CRLSP bandwidth modification procedure to execute needed bandwidth allocation changes on VNET CRLSPs. In the bandwidth allocation procedure the constraint-based routing label distribution protocol (CRLDP) [J00] or the resource reservation protocol (RSVP-TE) [AGBLSS00] could be used, for example, to specify appropriate parameters in the label request message:

- a) to request bandwidth allocation changes on each link in the CRLSP; and
- b) to determine if link bandwidth can be allocated on each link in the CRLSP.

If a link bandwidth allocation is not allowed, a notification message with an illustrative crankback parameter allows the ON to search out possible bandwidth allocation on another CRLSP. In particular, we illustrate an optional depth-of-search (DoS) parameter in the label request message to control the bandwidth allocation on individual links in a CRLSP. In addition, we illustrate an optional modify parameter in the label request message to allow dynamic modification of the assigned traffic parameters (such as peak data rate, committed data rate, etc.) of an already existing CRLSP. Finally, we illustrate a crankback parameter in the notification message to allow an edge node to search out additional alternate CRLSPs when a given CRLSP cannot accommodate a bandwidth request.

QoS resource management therefore can be applied on a per-flow (or per-call or per-connection-request) basis, or can be beneficially applied to traffic trunks (also known as "bandwidth pipes" or "virtual trunking") in the form of CRLSPs in IP-based networks or SVPs in ATM-based networks.

QoS resource management provides integration of services on a shared network, for many classes-of-service such as:

- CBR services including voice, 64-, 384-, and 1536-kbit/s N-ISDN switched digital data, international switched transit, priority defense communication, virtual private network, 800/free-phone, fiber preferred, and other services.
- Real-time VBR services including IP-telephony, compressed video, and other services.
- Non-real-time VBR services including WWW file transfer, credit card check, and other services.
- UBR services including voice mail, email, file transfer, and other services.

We now illustrate the principles of QoS resource management, which includes integration of many traffic classes, as discussed above.

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# ITU-T Recommendation E.360.3

## QoS routing and related traffic engineering methods – QoS resource management methods

### 1 Scope

The E.360.x series of Recommendations describes, analyzes, and recommends methods which control a network's response to traffic demands and other stimuli, such as link failures or node failures. The functions discussed and recommendations made related to traffic engineering (TE) are consistent with the definitions given in the Framework document of the Traffic Engineering Working Group (TWG) within the Internet Engineering Task Force (IETF):

Internet Traffic Engineering is concerned with the performance optimization of operational networks. It encompasses the measurement, modelling, characterization, and control of Internet traffic, and the application of techniques to achieve specific performance objectives, including the reliable and expeditious movement of traffic through the network, the efficient utilization of network resources, and the planning of network capacity.

The methods addressed in the E.360.x series include call and connection routing, QoS resource management, routing table management, dynamic transport routing, capacity management, and operational requirements. Some of the methods proposed herein are also addressed in or are closely related to those proposed in ITU-T Recs E.170 to E.179 and E.350 to E.353 for routing, E.410 to E.419 for network management and E.490 to E.780 for other traffic engineering issues.

The recommended methods are meant to apply to IP-based, ATM-based and TDM-based networks, as well as the interworking between these network technologies. Essentially all of the methods recommended are already widely applied in operational networks worldwide, particularly in PSTN networks employing TDM-based technology. However, these methods are shown to be extensible to packet-based technologies, that is, to IP-based and ATM-based technologies, and it is important that networks which evolve to employ these packet technologies have a sound foundation of methods to apply. Hence, it is the intent that the methods recommended in this series of Recommendations be used as a basis for requirements for specific methods and, as needed, for protocol development in IP-based, ATM-based and TDM-based networks, to implement the methods.

Hence, the methods encompassed in this series of Recommendations include:

- traffic management through control of routing functions, which include call routing (number/name translation to routing address), connection routing, QoS resource management, routing table management, and dynamic transport routing;
- capacity management through control of network design, including routing design;
- operational requirements for traffic management and capacity management, including forecasting, performance monitoring, and short-term network adjustment.

Results of analysis models are presented which illustrate the tradeoffs between various approaches. Based on the results of these studies as well as established practice and experience, TE methods are recommended for consideration in network evolution to IP-based, ATM-based and/or TDM-based technologies.

### 2 References

See clause 2/E.360.1.

### 3 Definitions

See clause 3/E.360.1.

### 4 Abbreviations

See clause 4/E.360.1.

## 5 Class-of-service identification, policy-based routing table derivation and QoS resource management steps

QoS resource management functions include class-of-service identification, routing table derivation, connection admission, bandwidth allocation, bandwidth protection, bandwidth reservation, priority routing, and priority queuing. In this clause we discuss class-of-service identification and routing-table derivation.

### 5.1 Class-of-Service identification

QoS resource management entails identifying class-of-service and class-of-service parameters, which may include, for example:

- service identity (SI);
- virtual network (VNET);
- link capability (LC); and
- QoS and traffic threshold parameters.

The SI describes the actual service associated with the call. The VNET describes the bandwidth allocation and routing table parameters to be used by the call. The LC describes the link hardware capabilities such as fiber, radio, satellite, and digital circuit multiplexing equipment (DCME), that the call should require, prefer, or avoid. The combination of SI, VNET, and LC constitute the class-of-service, which together with the network node number is used to access routing table data.

In addition to controlling bandwidth allocation, the QoS resource management procedures can check end-to-end transfer delay, delay variation, and transmission quality considerations such as loss, echo, and noise, as discussed in clause 10 below.

Determination of class-of-service begins with translation at the originating node. The number or name is translated to determine the routing address of the destination node. If multiple ingress/egress routing is used, multiple destination node addresses are derived for the call. Other data derived from call information, such as link characteristics, Q.931 message information elements, Information Interchange digits, and network control point routing information, are used to derive the class-of-service for the call.

### 5.2 Policy-based routing table derivation

Class-of-service parameters are derived through application of policy-based routing. Policy-based routing involves the application of rules applied to input parameters to derive a routing table and its associated parameters. Input parameters for applying policy-based rules to derive SI, VNET, and LC could include numbering plan, type of origination/destination network, and type of service. Policy-based routing rules may then be applied to the derived SI, VNET, and LC to derive the routing table and associated parameters.

Hence, policy-based routing rules are used in SI derivation which, for example, uses the type of origin, type of destination, signalling service type and dialed number/name service type to derive the SI. The type of origin can be derived normally from the type of incoming link to the connected network domain, connecting either to a directly connected (also known as nodal) customer equipment location, a switched access local exchange carrier, or an international carrier location.

Similarly, based on the dialed numbering plan, the type of destination network is derived and can be a directly connected (nodal) customer location if a private numbering plan is used (for example, within a virtual private network), a switched access customer location if a National Numbering Plan (NNP) number is used to the destination, or an international customer location, if the international E.164 numbering plan is used. Signalling service type is derived based on bearer capability within signalling messages, information digits in dialed digit codes, numbering plan or other signalling information, and can indicate long-distance service (LDS), virtual private network (VPN) service, ISDN switched digital service (SDS), and other service types. Finally, dialed number service type is derived based on special dialed number codes such as 800 numbers or 900 numbers and can indicate 800 (FreePhone) service, 900 (Mass-Announcement) service, and other service types. Type of origin, type of destination, signalling service type and dialed number service type are then all used to derive the SI.

The following are examples of the use of policy-based routing rules to derive class-of-service parameters. A long-distance service (LDS) SI, for example, is derived from the following information:

- 1) The type of origination network is a switched access local exchange carrier, because the call originates from a local exchange carrier node.
- 2) The type of destination network is a switched access local exchange carrier, based on the NNP dialed number.
- 3) The signalling service type is long-distance service, based on the national numbering plan (NNP).
- 4) The dialed number service type is not used to distinguish long-distance service SI.

An 800 (FreePhone) service SI, for example, is derived from similar information, except that:

- The dialed number service type is based on the 800 dialed "freephone" number to distinguish the 800 service SI.

A VPN service SI, for example, is derived from similar information, except that:

- The signalling service type is based on the originating customer having access to VPN intelligent network (IN)-based services to derive the VPN service SI.

A service identity mapping table uses the above four inputs to derive the service identity. This policy-based routing table is changeable by administrative updates, in which new service information can be defined without software modifications to the node processing. From the SI and bearer-service capability the SI/bearer-service-to-virtual network mapping table is used to derive the VNET.

Table A.1/E.360.2 illustrates the VNET mapping table. Here the SIs are mapped to individual virtual networks. Routing parameters for priority or key services are discussed further in the clauses below.

Link capability selection allows calls to be routed on links that have the particular characteristics required by these calls. A call can require, prefer, or avoid a set of link characteristics such as fiber transmission, radio transmission, satellite transmission, or compressed voice transmission. Link capability requirements for the call can be determined by the SI of the call, or by other information derived from the signalling message or from the routing number. The routing logic allows the call to skip those links that have undesired characteristics and to seek a best match for the requirements of the call.

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### 5.3 QoS resource management steps

The illustrative QoS resource management method consists of the following steps:

At the ON, the destination node (DN), SI, VNET, and QoS resource management information are determined through the number/name translation database and other service information available at the ON.

The DN and QoS resource management information are used to access the appropriate VNET and routing table between the ON and DN.

The connection request is set up over the first available path in the routing table with the required transmission resource selected based on the QoS resource management data.

In the first step, the ON translates the dialed digits to determine the address of the DN. If multiple ingress/egress routing is used, multiple destination node addresses are derived for the connection request. Other data derived from connection request information includes link characteristics, Q.931 message information elements, information interchange (II) digits, and service control point (SCP) routing information, and are used to derive the QoS resource management parameters (SI, VNET, LC, and QoS/traffic thresholds). SI describes the actual service associated with the connection request; VNET describes the bandwidth allocation and routing table parameters to be used by the connection request, and the LC describes the link characteristics including fiber, radio, satellite, and voice compression that the connection request should require, prefer, or avoid. Each connection request is classified by its SI. A connection request for an individual service is allocated an equivalent bandwidth equal to EQBW and routed on a particular VNET. For CBR services the equivalent bandwidth EQBW is equal to the average or sustainable bit rate. For VBR services the equivalent bandwidth EQBW is a function of the sustainable bit rate, peak bit rate, and perhaps other parameters. For example, EQBW equals 64 kbit/s of bandwidth for CBR voice connections, 64 kbit/s of bandwidth for CBR ISDN switched digital 64-kbit/s connections, and 384-kbit/s of bandwidth for CBR ISDN switched digital 384-kbit/s connections. (Equivalent bandwidth and connection admission control are further discussed in clause 9.)

In the second step, the SI value is used to derive the VNET. In the multi-service, QoS resource management network, bandwidth is allocated to individual VNETs which is protected as needed but otherwise shared. Under normal non-blocking/delay network conditions, all services fully share all available bandwidth. When blocking/delay occurs for VNET *i*, bandwidth reservation acts to prohibit alternate-routed traffic and traffic from other VNETs from seizing the allocated capacity for VNET *i*. Associated with each VNET are average bandwidth (BW<sub>avg</sub>) and maximum bandwidth (BW<sub>max</sub>) parameters to govern bandwidth allocation and protection, which are discussed further in clause 6. As discussed, LC selection allows connection requests to be routed on specific transmission links that have the particular characteristics required by a connection request.

In the third step, the VNET routing table determines which network capacity is allowed to be selected for each connection request. In using the VNET routing table to select network capacity, the ON selects a first choice path based on the routing table selection rules. Whether or not bandwidth can be allocated to the connection request on the first choice path is determined by the QoS resource management rules given below. If a first choice path cannot be accessed, the ON may then try alternate paths determined by FR, TDR, SDR, or EDR path selection rules outlined in ITU-T Rec. E.360.2. Whether or not bandwidth can be allocated to the connection request on the alternate path again is determined by the QoS resource management rules now described.