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

International routing plan

**Framework for QoS routing and related traffic
engineering methods for IP-, ATM-, and
TDM-based multiservice networks**

ITU-T Recommendation E.360.1

ITU-T E-SERIES RECOMMENDATIONS

OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

INTERNATIONAL OPERATION	
Definitions	E.100–E.103
General provisions concerning Administrations	E.104–E.119
General provisions concerning users	E.120–E.139
Operation of international telephone services	E.140–E.159
Numbering plan of the international telephone service	E.160–E.169
International routing plan	E.170–E.179
Tones in national signalling systems	E.180–E.189
Numbering plan of the international telephone service	E.190–E.199
Maritime mobile service and public land mobile service	E.200–E.229
OPERATIONAL PROVISIONS RELATING TO CHARGING AND ACCOUNTING IN THE INTERNATIONAL TELEPHONE SERVICE	
Charging in the international telephone service	E.230–E.249
Measuring and recording call durations for accounting purposes	E.260–E.269
UTILIZATION OF THE INTERNATIONAL TELEPHONE NETWORK FOR NON-TELEPHONY APPLICATIONS	
General	E.300–E.319
Phototelegraphy	E.320–E.329
ISDN PROVISIONS CONCERNING USERS	E.330–E.349
INTERNATIONAL ROUTING PLAN	E.350–E.399
NETWORK MANAGEMENT	
International service statistics	E.400–E.409
International network management	E.410–E.419
Checking the quality of the international telephone service	E.420–E.489
TRAFFIC ENGINEERING	
Measurement and recording of traffic	E.490–E.505
Forecasting of traffic	E.506–E.509
Determination of the number of circuits in manual operation	E.510–E.519
Determination of the number of circuits in automatic and semi-automatic operation	E.520–E.539
Grade of service	E.540–E.599
Definitions	E.600–E.649
Traffic engineering for IP-networks	E.650–E.699
ISDN traffic engineering	E.700–E.749
Mobile network traffic engineering	E.750–E.799
QUALITY OF TELECOMMUNICATION SERVICES: CONCEPTS, MODELS, OBJECTIVES AND DEPENDABILITY PLANNING	
Terms and definitions related to the quality of telecommunication services	E.800–E.809
Models for telecommunication services	E.810–E.844
Objectives for quality of service and related concepts of telecommunication services	E.845–E.859
Use of quality of service objectives for planning of telecommunication networks	E.860–E.879
Field data collection and evaluation on the performance of equipment, networks and services	E.880–E.899

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation E.360.1

Framework for QoS routing and related traffic engineering methods for IP-, ATM-, and TDM-based multiservice networks

Summary

The E.360.x series of Recommendations describes, analyses, 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.360.1 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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Recommendation E.360.1 – Framework for QoS routing and related traffic engineering methods for IP-, ATM-, and TDM-Based multiservice networks

- 1 Scope
- 2 References
- 3 Definitions
- 4 Abbreviations
- 5 Traffic engineering model
- 6 Traffic models
- 7 Traffic management functions
- 8 Capacity management functions
- 9 Traffic engineering operational requirements
- 10 Traffic engineering modelling and analysis
- 11 Conclusions/recommendations
- 12 Recommended TE/QoS methods for multiservice networks

Bibliography

Recommendation E.360.2 – QoS routing and related traffic engineering methods – Call routing and connection routing methods

- 1 Scope
- 2 References
- 3 Definitions
- 4 Abbreviations
- 5 Call routing methods
- 6 Connection (bearer-path) routing methods
- 7 Hierarchical Fixed Routing (FR) path selection
- 8 Time-Dependent Routing (TDR) path selection
- 9 State-Dependent Routing (SDR) path selection
- 10 Event-Dependent Routing (EDR) path selection
- 11 Interdomain routing
- 12 Conclusions/recommendations

Annex A – Modelling of traffic engineering methods

Recommendation E.360.3 – QoS routing and related traffic engineering methods – QoS resource management methods

- 1 Scope
- 2 References
- 3 Definitions
- 4 Abbreviations

- 5 Class-of-service identification, policy-based routing table derivation and QoS resource management steps
- 6 Dynamic bandwidth allocation, protection, and reservation principles
- 7 Per-virtual-network bandwidth allocation, protection, and reservation
- 8 Per-flow bandwidth allocation, protection, and reservation
- 9 Packet-level traffic control
- 10 Other QoS resource management constraints
- 11 Interdomain QoS resource management
- 12 Conclusions/recommendations

Annex A – Modelling of traffic engineering methods

Recommendation E.360.4 – QoS routing and related traffic engineering methods – Routing table management methods and requirements

- 1 Scope
- 2 References
- 3 Definitions
- 4 Abbreviations
- 5 Routing table management for IP-based networks
- 6 Routing table management for ATM-based networks
- 7 Routing table management for TDM-based networks
- 8 Signalling and information exchange requirements
- 9 Examples of internetwork routing
- 10 Conclusions/recommendations

Annex A – Modelling of traffic engineering methods

Recommendation E.360.5 – QoS routing and related traffic engineering methods – Transport routing methods

- 1 Scope
- 2 References
- 3 Definitions
- 4 Abbreviations
- 5 Dynamic transport routing principles
- 6 Dynamic transport routing examples
- 7 Reliable transport network design
- 8 Conclusions/recommendations

Annex A – Modelling of traffic engineering methods

Recommendation E.360.6 – QoS routing and related traffic engineering methods – Capacity management methods

- 1 Scope
- 2 References
- 3 Definitions
- 4 Abbreviations
- 5 Link capacity design models
- 6 Shortest path selection models
- 7 Multihour network design models
- 8 Day-to-day load variation design models
- 9 Forecast uncertainty/reserve capacity design models
- 10 Meshed, sparse, and dynamic-transport design models
- 11 Conclusions/recommendations

Annex A – Modelling of traffic engineering methods

Recommendation E.360.7 – QoS routing and related traffic engineering methods – Traffic engineering operational requirements

- 1 Scope
- 2 References
- 3 Definitions
- 4 Abbreviations
- 5 Traffic management
- 6 Capacity management – Forecasting
- 7 Capacity management – Daily and weekly performance monitoring
- 8 Capacity management – Short-term network adjustment
- 9 Comparison of off-line (TDR) versus on-line (SDR/EDR) TE methods
- 10 Conclusions/recommendations

Introduction

Traffic engineering (TE) is an indispensable network function which controls a network's response to traffic demands and other stimuli, such as network failures. TE encompasses

- traffic management through control of routing functions, which include number/name translation to routing address, connection routing, routing table management, QoS resource management, and dynamic transport routing.
- capacity management through control of network design.

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. The long awaited data revolution is occurring, with the extremely rapid growth of data services such as IP-multimedia and frame-relay services. Within these categories of networks and services supported by IP, ATM, and TDM protocols have evolved various TE methods. The TE mechanisms are covered in the Recommendation, and a comparative analysis and performance evaluation of various TE alternatives is presented. Finally, operational requirements for TE implementation are covered.

We begin this Framework Recommendation with a general model for TE functions, which include traffic management and capacity management functions responding to traffic demands on the network. We then present a traffic-variations model which these TE functions are responding to. Next we outline traffic management functions which include call routing (number/name translation to routing address), connection or bearer-path routing, QoS resource management, routing table management, and dynamic transport routing. These traffic management functions are further developed in ITU-T Recs E.360.2, E.360.3, E.360.4, and E.360.5. We then outline capacity management functions, which are further developed in ITU-T Rec. E.360.6. Finally we briefly summarize TE operational requirements, which are further developed in ITU-T Rec. E.360.7.

In ITU-T Rec. E.360.2, we present models for call routing, which entails number/name translation to a routing address associated with service requests, and also compare various connection (bearer-path) routing methods. In ITU-T Rec. E.360.3, we examine QoS resource management methods in detail, and illustrate per-flow versus per-virtual-network (or per-traffic-trunk or per-bandwidth-pipe) resource management and the realization of multiservice integration with priority routing services. In ITU-T Rec. E.360.4, we identify and discuss routing table management approaches. This includes a discussion of TE signalling and information exchange requirements needed for interworking across network types, so that the information exchange at the interface is compatible across network types. In ITU-T Rec. E.360.5 we describe methods for dynamic transport routing, which is enabled by the capabilities such as optical cross-connect devices, to dynamically rearrange transport network capacity. In ITU-T Rec. E.360.6 we describe principles for TE capacity management, and in ITU-T Rec. E.360.7 we present TE operational requirements.

ITU-T Recommendation E.360.1

Framework for QoS routing and related traffic engineering methods for IP-, ATM-, and TDM-Based multiservice networks

1 Scope

The E.360.x series of Recommendations describes, analyses, 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 (TEWG) within the Internet Engineering Task Force (IETF):

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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, which illustrate the tradeoffs between various approaches are presented. 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

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.

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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 autonomous system: A routing domain which has a common administrative authority and consistent internal routing policy. An AS may employ multiple intradomain routing protocols and interfaces to other ASs via a common interdomain routing protocol.

3.3 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).

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

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

3.6 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).

3.7 class of service: Characteristics of a service such as described by service identity, virtual network, link capability requirements, QoS & traffic threshold parameters.

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 (CAC): 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 setup 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, & 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 variable:** Any performance variable (such as congestion, delay, etc.) which is perceivable by a user.
- 3.31 route:** A set of paths connecting the same originating node-destination node pair.
- 3.32 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).
- 3.33 routing table:** Describes the path choices and selection rules to select one path out of the route for a connection/bandwidth-allocation request.
- 3.34 switching:** Denotes connection of an input port to an output port within a given node through the switching fabric.
- 3.35 traffic engineering:** Encompasses traffic management, capacity management, traffic measurement and modelling, network modelling, and performance analysis.
- 3.36 traffic engineering methods:** Network functions which support traffic engineering and include call routing; connection routing, QoS resource management, routing table management, and capacity management.

3.37 traffic stream: A class of connection requests with the same traffic characteristics.

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

3.39 transport: Refers to the transmission of bits or packets on the physical layer (layer 1) between 2 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)).

3.40 via node: An intermediate node in a path within a given network.

4 Abbreviations

This Recommendation uses the following abbreviations:

AAR	Automatic Alternate Routing
ABR	Available Bit Rate
ADR	Address
AESA	ATM End System Address
AFI	Authority and Format Identifier
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
BWIP	Bandwidth in Progress
BWOF	Bandwidth Offered
BWOV	Bandwidth Overflow
BWPC	Bandwidth Peg Count
CAC	Call (or Connection) Admission Control
CBK	Crankback
CBR	Constant Bit Rate
CCS	Common Channel Signalling
CIC	Call Identification Code
CRLDP	Constraint-based Routing Label Distribution Protocol

CRLSP	Constraint-based Routing Label Switched Path
DADR	Distributed Adaptive Dynamic Routing
DAR	Dynamic Alternate Routing
DCC	Data Country Code
DCR	Dynamically Controlled Routing
DIFFSERV	Differentiated Services
DN	Destination Node
DNHR	Dynamic Non-Hierarchical Routing
DoS	Depth-of-Search
DSP	Domain Specific Part
DTL	Designated Transit List
EDR	Event Dependent Routing
ER	Explicit Route
FR	Fixed Routing
GCAC	Generic Call Admission Control
GOS	Grade of Service
HL	Heavily Loaded
IAM	Initial Address Message
ICD	International Code Designator
IDI	Initial Domain Identifier
IDP	Initial Domain Part
IE	Information Element
IETF	Internet Engineering Task Force
II	Information Interchange
ILBW	Idle Link Bandwidth
INRA	International Network Routing Address
IP	Internet Protocol
IPDC	Internet Protocol Device Control
LBL	Link Blocking Level
LC	Link Capability
LDP	Label Distribution Protocol
LL	Lightly Loaded
LLR	Least Loaded Routing
LSA	Link State Advertisement
LSP	Label Switched Path
MEGACO	Media Gateway Control
MOD	Modify

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