International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.2175
(11/2008)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Quality of Service and performance

---

Centralized RACF architecture for MPLS core networks

Recommendation ITU-T Y.2175

ITU-T

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	**Y.2100–Y.2199**
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Numbering, naming and addressing	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899

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

Recommendation ITU-T Y.2175

Centralized RACF architecture for MPLS core networks

Summary

The architectural structure of a centralized resource admission and control functions (RACF) is considered in Recommendation ITU-T Y.2175. RACF is comprised of a transport resource control functional entity (TRC-FE) and a policy decision functional entity (PD-FE). This Recommendation defines an architecture, which considers a centralized RACF resulting from a centralized TRC-FE, specifies supporting requirements, and describes the resource reservation process for this specific architecture.

Source

Recommendation ITU-T Y.2175 was approved on 13 November 2008 by ITU-T Study Group 13 (2009-2012) under Recommendation ITU-T A.8 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). 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.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

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, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

© ITU 2009

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

CONTENTS

Recommendation ITU-T Y.2175

Centralized RACF architecture for MPLS core networks

1 Scope

[ITU-T Y.2111] defines the general requirements for resource and admission control functions for next generation networks (NGNs). These requirements are independent of the underlying transport technology.

Multiprotocol label switching (MPLS) is considered to be a key transport technology in core networks. In particular, networks which use MPLS with traffic engineering (MPLS-TE) capabilities provide significant assurance that the delivery of the desired quality of service (QoS) for a variety of services and applications will occur.

Resource and admission control functions (RACF) are used to control the flow of traffic from access networks into the MPLS core [ITU-T Y.2111]. A centralized architectural structure of one RACF functional entity, the transport resource control functional entity (TRC-FE), is considered in this Recommendation. In this architectural arrangement, MPLS transport resource is monitored and controlled by the centralized control entity. This Recommendation defines the centralized architecture for the TRC-FE and specifies supporting requirements.

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.

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2006), *Functional requirements and architecture of the NGN release 1*.

[ITU-T Y.2111] Recommendation ITU-T Y.2111 (2006), *Resource and admission control functions in next generation networks*.

[IETF RFC 3814] IETF RFC 3814 (2004), *Multiprotocol Label Switching (MPLS) Forwarding Equivalence Class To Next Hop Label Forwarding Entry (FEC-To-NHLFE) Management Information Base (MIB).*

3 Definitions

The definitions for the terms used in this Recommendation can be found in [ITU-T Y.2111].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations.

CAC Connection Admission Control

E-LSP EXP inferred LSP

FEC Forwarding Equivalence Class

FTN FEC-To-NHLFE

LER Label Edge Router

L-LSP Label inferred LSP

LSP Label Switching Path

LSR Label Switching Router

MPLS MultiProtocol Label Switching

NHLFE Next Hop Label Forwarding Entry

NMS Network Management System

OAM Operation, Administration and Maintenance

OSS Operations and Support System

PD-FE Policy Decision Functional Entity

PE-FE Policy Enforcement Functional Entity

QoS Quality of Service

RACF Resource and Admission Control Functions

RIR Resource Initiation Request

TE Traffic Engineering

TRC-FE Transport Resource Control Functional Entity

TRE-FE Transport Resource Enforcement Functional Entity

5 Centralized RACF architecture

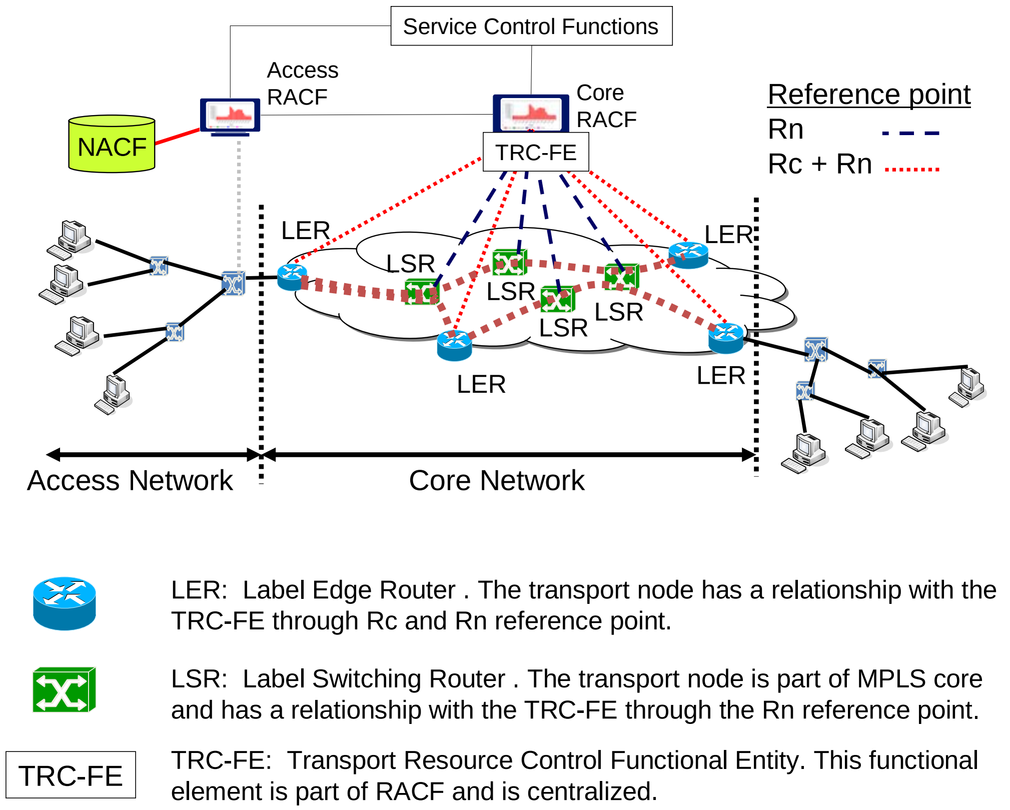

Figure 1 – Centralized RACF architecture

Figure 1 describes the centralized RACF architecture for the MPLS-based core network. In the architecture, the access network aggregates the data traffic to the core network. The edge nodes of the core network are connected by pre-provisioned LSPs or TE tunnels. At the edge of the core network, the traffic of multiple flows is aggregated into these pre-provisioned LSPs or tunnels.

This Recommendation considers the case where the RACF of the MPLS network is centralized. The RACF is comprised of a TRC-FE and a PD-FE. In the centralized architecture, the TRC-FE is located in the centralized control entity, monitors the resource status of the network, and adjusts the bandwidth of the LSP. The LER and LSR are responsible for the role of the TRE-FE in enforcing aggregate bandwidth. The TRC-FE interacts with the LERs through the Rc and Rn reference points and also interacts with the LSR through the Rn reference point. The TRC-FE collects the network resource and status information through the Rc reference point to the LER. The TRC-FE adjusts the LSP bandwidth through the Rn reference point to the LER and LSR. The Rn reference point is also used for the TRC-FE to update the flow to the LSP mapping in the LER.

The admission decision is made by the RACF based on the available bandwidth of the pre-provisioned LSP tunnels in the core. The RACF determines the mapping of the individual flow to the pre-provisioned LSP. The QoS can be monitored at the LSP level. The RACF monitors the network resource in the LSP and adjusts the bandwidth of the established LSP.

The number of admission requests in the core network is high. The resource checking between the PD-FE and the TRC-FE for connection admission control needs to process the high number of resource requests. In the centralized architecture, by placing the TRC-FE and PD-FE in the centralized entity, the call level admission decision (especially for the resource check between the TRC-FE and the PD-FE) can be done efficiently. An example of an end-to-end control scenario in the centralized architecture is described in Appendix I.

6 Required functions

[ITU-T Y.2111] defines the control of transport independent aspects. This Recommendation describes the aspects that are specific to the MPLS transport. The TRC-FE and the TRE-FE are the functional entities responsible for the MPLS-specific resource control. This clause describes the required functions of the two functional entities – the TRC-FE and the TRE-FE – and the corresponding reference points – Rc and Rn.

6.1 Resizing established LSP

It is recommended that the TRC-FE request the LSP resource adjustment based on the resource status of the MPLS network or the rejection ratio of the admission request. The resizing operation does not occur on every admission decision of the PD-FE.

It is required that the TRC-FE adjust the bandwidth of an established LSP by (1) changing the bandwidth configuration of the LERs and LSRs or by (2) instructing the ingress LER to initiate path-coupled signalling. In the first case, the TRC-FE instructs the LERs and LSRs along the LSP to modify the bandwidth of the LSP. In the second case, the TRC-FE instructs the ingress LER to initiate the path-coupled signalling – e.g., aggregate RSVP-TE [b-IETF RFC 4804] and clause 7.2.

6.2 Mapping flow to the LSP

It is recommended that the flows be mapped into an LSP tunnel at the edge of the LSP network. Flow-to-LSP mapping is controlled by the TRC-FE.

Flow-to-LSP mapping occurs at the ingress LER as defined in [IETF RFC 3814]. The FTN (forwarding equivalence class to next hop label forwarding entry (FEC-To-NHLFE)) table defines the mapping rule from the data flow to the LSP. In the IPv4 case, the mapping rule is defined by IP classifier consisting of combination of 5-tuple (source address, destination address, source port, destination port, and protocol) and the DSCP.

The TRC-FE maintains the LSP/TE tunnel information. Upon receiving resource request from the PD-FE, the TRC-FE selects the right LSP/TE tunnel that can best provide the desired priority and QoS, instructs the TRE-FE updating the FTN table to map the media flow into that LSP/TE tunnel, and sends the response to the PD-FE with success. Mapping of flow to the LSP is enforced by the TRE-FE at the ingress LER based on the FTN table which is created and maintained in the TRE-FE under the instruction of the TRC-FE.

The TRC-FE controls the FTN table at the ingress LER. The mapping control operation does not have to occur on every PD-FE admission decision. A mapping rule can be pre-provisioned based on network policy or set up dynamically per resource request.

6.3 Resource and topology monitoring of the MPLS network

The bandwidth adjustment of the established LSP occurs based on the resource status of the network. The resource status is recommended to be obtained from the management system or from embedded OAM capability of the transport equipment.

The TRC-FE is required to collect the basic performance parameters per LSP – i.e., number of sent packets, number of bytes sent, and number of dropped packets – for an LSP tunnel. It is recommended that the TRC-FE collect the topology derived from the hop list – i.e., the LSP route hop [b-IETF RFC 3812].

It is optional that the TRC-FE monitor the network status using the MPLS OAM functions defined in [b-ITU-T Y.1711]. The OAM function provides the connectivity verification and performance information. The TRC-FE is required to receive periodic reports about the performance monitoring information and/or event reports when a network defect occurs or is cleared. This report can be received directly from the MPLS transport or indirectly through the management system.

6.4 Required functions in the TRC-FE

In addition to the general requirements in [ITU-T Y.2111], it is required for the TRC-FE to support the following functions for resource control of the MPLS networks.

– **Interacting with network monitoring functions**: The TRC-FE interacts with the OAM functions in the transport node, or a transport MIB agent to collect the resource and network status information of the MPLS network.

– **Resizing bandwidth of existing LSP**: The TRC-FE adjusts bandwidth of existing LSP/TE tunnels.

– **Controlling mapping flow to LSP**: The TRC-FE controls mapping flow to the LSP by adding and removing the FTN table entry in the TRE-FE.

– **Collecting the resource state and topology**: The TRC-FE collects the network resource status and topology information from the LER and LSR.

6.5 Required functions in the TRE-FE

It is required for the TRE-FE to support the following functions for resource control of the MPLS networks:

– **Mapping of flow to the LSP**: The TRE-FE at the head end of the LSP will maintain the FTN table under the control of the TRC-FE and map flow to the LSP based on the FTN table.

– **Reporting the resource and network status**: The TRE-FE reports the resource and network status to the TRC-FE based on the observation of the resource status of the LSP.

– **Enforcing the transport resource policy**: The TRE-FE enforces the transport resource policy rules instructed by the TRC-FE, such as mapping a service flow to an appropriate LSP, the FTN updating scheme, and adjusting the LSP bandwidth.

6.6 Requirements for Rc and Rn

6.6.1 Rc reference point

The Rc reference point is used to collect the network topology and resource information from the MPLS transport.

The Rc reference point is used for the TRC-FE interface to either the LER or the management system. The Rc is used to collect the basic performance parameters per LSP – i.e., the number of sent packets, the number of bytes sent, and the umber of dropped packets – for a MPLS tunnel. When the MPLS network supports the OAM functions, it is optional for the Rc to collect more information on LSP quality such as connectivity and delay performance. It is recommended that topology be derived from the hop list – i.e., the LSP route hop [b-IETF RFC 3812]. The TRC-FE collects the topology information from the individual LSRs or the management system.

6.6.1.1 Information components in the Rc

Tables 1 to 3 describe the information components for the Rc reference point.

Table 1 – Identifier related information component (Rc)

Information component	Description
Tunnel identifier	Unique identifier for an LSP tunnel
Transaction index	Unique identifier for the request/response transaction between the TRC-FE and the TRE-FE
TRC-FE-identifier	Unique identifier for the requesting TRC-FE
TRE-FE –identifier	Unique identifier for the receiving TRE-FE (i.e., LER or LSR)

Table 2 – Topology related information component (Rc)

Information component	Description
Tunnel-route-hop	List of hops (IP address or identifier) for the actual LSP path

Table 3 – Tunnel resource status related information component (Rc)

Information component	Description
Tunnel-performance	Set of performance parameters for the LSP tunnel
– Packet-sent	Total number of packets that an LSR or LER sent to an LSP
– Packet-dropped	Total number of packets that an LSR or LER dropped for an LSP
– Byte-sent	Total number of bytes that an LSR or LER sent to an LSP
– One-way-delay	One-way delay in ms
– Two-way-delay	Two-way delay in ms
– Average-one-way-delay	Average one-way delay value in ms
– Average-two-way-delay	Average two-way delay value in ms
Tunnel-status	Tunnel state (e.g., normal, loss of connectivity)

6.6.1.2 Messages

It is required that the following messages be exchanged over the Rc reference point.

Topology-related messages

– Topology-request: This message requests the topology information from the LER. This message consists of following information components:
  - Transaction-index
  - TRC-FE-identifier
  - TRE-FE-identifier (optional)
  - Tunnel-identifier
– Topology-response: Response to the topology request. This message consists of the following information components:
  - Transaction-index
  - TRC-FE-identifier
  - TRE-FE-identifier (optional)
  - Tunnel-route-hop

Resource-related messages

– Resource-status-request: Request the resource state of a LSP. This message consists of the following information components:
  - Transaction-index
  - TRC-FE-identifier
  - TRE-FE-identifier (optional)
  - Tunnel-identifier
– Resource-status-response: Response to the resource-status-request. This message consists of the following information components:
  - Transaction-index
  - TRC-FE-identifier
  - TRE-FE-identifier (optional)
  - Tunnel-identifier
  - Tunnel-performance
  - Tunnel-status
– LSP-status-report: The LER or LSR sends a report when the LSP performance is changed. This message consists of the following information components:
  - Transaction-index
  - TRC-FE-identifier
  - TRE-FE-identifier (optional)
  - Tunnel-identifier
  - Tunnel-performance
  - Tunnel-status

6.6.2 Rn reference point

The Rn reference point is used to control the transport element (i.e., LER and LSR) for the LSP.

The Rn is required to support the following functions:

– Control mapping of flows to the LSP: The TRC-FE controls the setup of the FTN table in the TRE-FE at the head end of the LSP through the Rn reference point. The TRC-FE instructs the TRE-FE to map the flows into the LSP, and the TRE-FE maintains its FTN table accordingly.

– Aggregate resource control for the LSP: In the transit nodes of the traffic aggregation, the traffic resource is defined by the traffic parameters. The TRC-FE is required to control the aggregate resource. The resource parameters for the LSP include the maximum rate, mean rate, maximum burst, mean burst, resource weight, and excess burst size.

6.6.2.1 Information components in the Rn

Tables 4 to 6 describe the information components for the Rn reference point.

Table 4 – Identifier related information component (Rn)

Information component	Description
Tunnel identifier	Unique identifier for an LSP tunnel
Transaction index	Unique identifier for the request/response transaction between the TRC-FE and the TRE-FE
FTN-entry-identifier	Unique identifier for a FTN-matching-classifier
TRC-FE-identifier	Unique identifier for the TRC-FE sending the request
TRE-FE-identifier	Unique identifier for the receiving TRE-FE (i.e., LER or LSR)

Table 5 – FTN related information component (Rn)

Information component	Description
FTN-matching-classifier	Identifies the flows aggregated into the LSP
– classifier-rule-priority	Determines the order of classifier. Higher value indicates higher priority. (0-255)
– ip-address-source-min	Minimum value of the source IP address
– ip-address-source-max	Maximum value of the source IP address
– ip-address-destination-min	Minimum value of the destination IP address
– ip-address-destination-max	Maximum value of the destination IP address
– port-source-min	Minimum value of the source port
– port-source-max	Maximum value of the source port
– port-destination-min	Minimum value of the destination port
– port-destination-max	Maximum value of the destination port
– protocol-number	The IP protocol to match against the IPv4 protocol number
– DSCP	DiffServ Code Point value
Next-hop-identifier	Identifier for the next hop LSR

Note that if any classifier field is omitted, the comparison of the corresponding entry is irrelevant.

Table 6 – Aggregate resource control related information component (Rn)

Information component	Description
Tunnel-resource	Defines the LSP tunnel resource
– Maximum-rate	Maximum rate for the LSP tunnel (bits/s)
– Mean-rate	Mean rate for the LSP tunnel (bits/s)
– Max-burst	Maximum burst size for the LSP tunnel (bytes)
– Mean-burst	Mean burst size for the LSP tunnel (bytes)
– Resource-weight	Weight for using excess bandwidth
– Excess-burst-size	Excess burst size (bytes)
Control-method	Identifies the LSP resource control method – single node control or in-band signalling along the LSP

6.6.2.2 Messages

It is required that following messages are exchanged over the Rn reference point:

Flow mapping related messages

– Add-FTN-entry-request: This message requests the addition of an FTN entry in the LER. This message consists of the following information components:
  - Transaction-index
  - TRC-FE-identifier
  - Tunnel-identifier
  - FTN-entry-identifier
  - FTN-matching-classifier

  Once the request is successfully completed, the additional group of flows specified by the FTN-matching-classifier will be aggregated to the tunnel identified by the Tunnel-identifier.

– Add-FTN-entry-response: Response to Add-FTN-entry-request. This message consists of the following information components:
  - Transaction-index
  - TRC-FE-identifier
  - FTN-entry-identifier
  - Result

– Remove-FTN-entry-request: This message requests the deletion of the FTN entry in LER. This message consists of the same information components as the Add-FTN-entry-request except FTN-matching-classifier.

– Remove-FTN-entry-response: This message responds to the Remove-FTN-entry-request. This message consists of the same information components as the Add-FTN-entry-response.

– Modify-FTN-entry-request: This message requests the modification of FTN entry in LER. This message consists of the same information components as the Add-FTN-entry-request.

– Modify-FTN-entry-response: This message responds to the Modify-FTN-entry-request. This message consists of the same information components as the Add-FTN-entry-response.

Tunnel aggregate resource control related messages

– Modify-tunnel-resource-request: This message requests a change of the tunnel resource in the LER and LSR. This message consists of the following information components:
  - Transaction-index
  - TRC-FE-identifier
  - Tunnel-identifier
  - Tunnel-resource-entry
  - control-method

– Modify-tunnel-resource-response: This message responds to the Modify-tunnel-resource-request. This message consists of the following information components:
  - Transaction-index
  - TRC-FE-identifier
  - Tunnel-identifier
  - Result

7 Resource control procedure in the MPLS network

The LSPs/tunnels are set up with the normal NMS/OAM processes between pairs of edge routers according to predetermined network traffic patterns. Once the LSP tunnel is established, the TRC-FE adjusts the reserved bandwidth of the LSP tunnel. Bandwidth reservation in the LSPs/tunnels is done in two modes – dynamic and static:

– Dynamic bandwidth reservation: In this case, the tunnel bandwidth control is tightly coupled with the resource request of the media flow. It is recommended that aggregate bandwidth be adjusted when media flow is admitted or released. The tunnel bandwidth is reserved in aggregated fashion to support multiple sessions in the LSP/tunnel per pre-established policy rules.

– Static bandwidth reservation: In this case, a predetermined amount of bandwidth is reserved when the LSP/tunnel is pre-established. Tunnel bandwidth control is independent of the call by call admission control. Some incoming flows are recommended to be rejected. The TRC-FE is required to perform the bandwidth adjustment based on network condition. For example, when the TRC-FE observes that resource request is rejected because of the bandwidth shortage, the TRC-FE initiates increasing the tunnel bandwidth. The amount of bandwidth is estimated from historical traffic patterns. It is assumed that all bandwidth would be utilized by simultaneous flows very rarely.

The procedure for bandwidth reservation is described in clause 7.2.

7.1 Resource and admission control in MPLS network

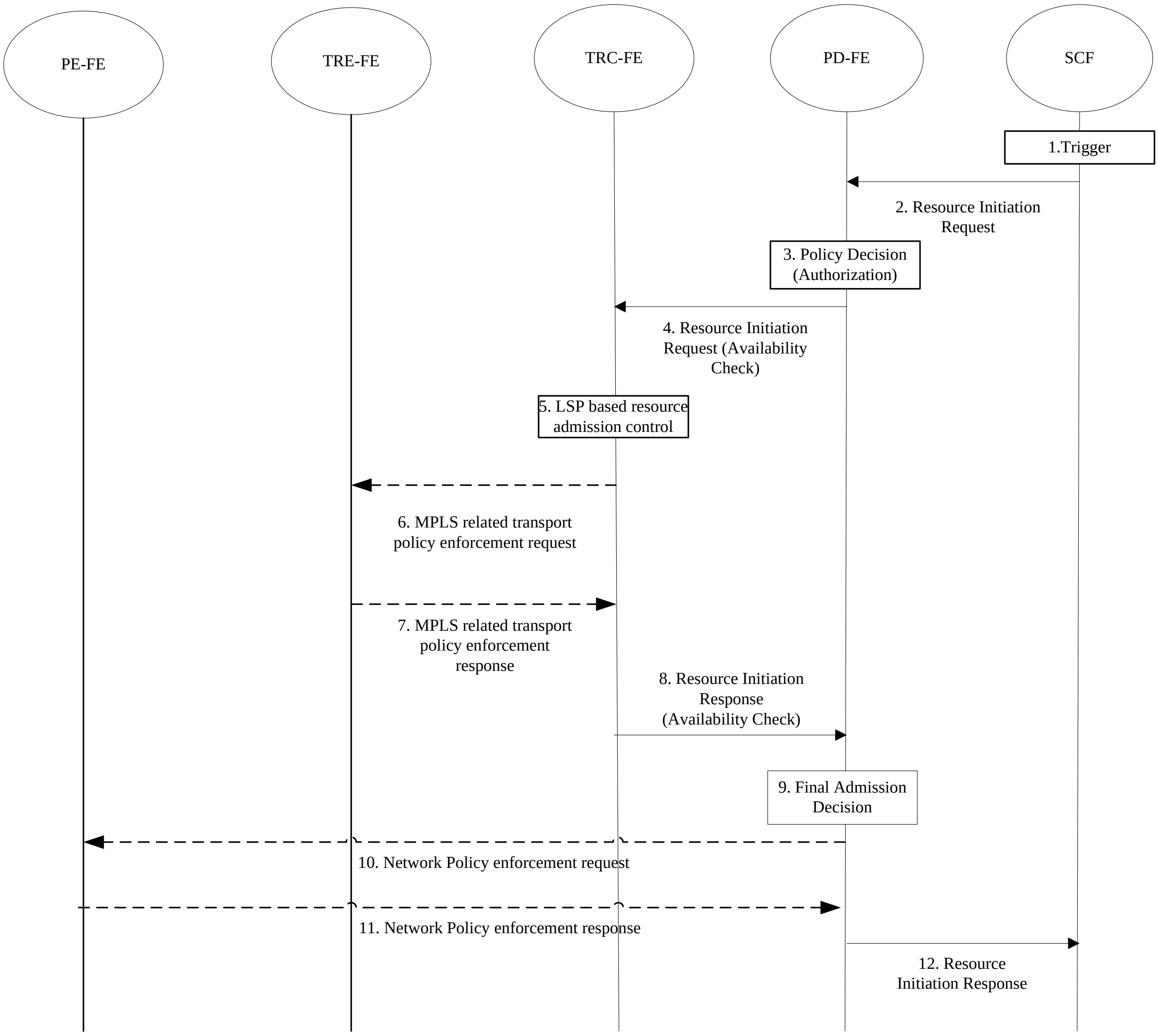

Figure 2 − Resource admission control procedure in the MPLS network

(1) A resource initiation request (reservation) (i.e. RIR (reservation)) is usually triggered by a service establishment event or an internal action in the SCF. An example event is the receipt or generation of a service signalling message by the SCF.

(2) The SCF determines or derives the QoS requirement parameters (such as bandwidth, class of service) for the media flows of a given service. The SCF then sends a RIR (reservation) with the media flow description and its QoS parameters to the PD-FE across the Rs reference point for QoS resource authorization and reservation.

(3) Upon receiving the RIR (reservation), the PD-FE is required to authorize the required QoS resources for the media flow. The PD-FE checks if the media flow description and the required QoS resources are consistent with network policy rules held in the PD-FE and the transport subscription information held in the NACF.

(4) The PD-FE sends a RIR (availability check) to the TRC-FE registered in the PD-FE to check resource availability in the involved network.

(5) The TRC-FE performs the LSP-based resource admission control. The TRC-FE checks if required QoS resources, such as bandwidth and delay requirement, are acceptable under the currently available network resource. If the requested resource is available, the request will be accepted directly. If the request is not admitted, the PD-FE sends a RIP with the rejection reason back to the SCF after step 8.

(6) It is optional for the TRC-FE to send the MPLS related transport policy enforcement request to the TRE-FEs to install flow to the LSP mapping rule and adjust the LSP bandwidth.

(7) The TRE-FEs install and enforce the LSP related policy and send response back to the TRC-FE. Note that steps 6 and 7 are optional. Steps 6 and 7 are not required when the flow-to-LSP mapping rule is pre-provisioned based on network policy, and current available bandwidth of the LSP tunnel is sufficient for accepting the additional flow.

(8) The TRC-FE sends a resource initiation response (availability check) to the PD-FE.

(9) The PD-FE makes the final admission decision based on the response. If the request is not admitted, the PD-FE sends a RIP with the rejection reason back to the SCF.

(10) It is optional for the PD-FE to send a network policy enforcement request to install the final admission decisions in the PE-FE. The RIR from the PD-FE requests the admission decisions to be enforced immediately (i.e., reservation + commitment), or requests the installation of admission decisions only (i.e., reservation only) and awaits a separate network policy enforcement request (commitment) later for gate opening and resource allocation.

(11) The PE-FE installs and enforces the final admission decisions sent from the PD-FE and sends a network policy enforcement response back to the PD-FE.

(12) The PD-FE sends a RIP back to the SCF.

The connection setup procedure needs to be simple in the core network because the number of service requests will be very high. To make the control procedure more scalable, steps 6-7 and 10-11 can be skipped. An example of simplified admission control scenario in the centralized architecture is described in Appendix I.

7.2 Procedure for aggregate bandwidth adjustment

The tunnel resource control can be dynamic or static. In the static case, the operation of aggregate bandwidth adjustment is required to be done independently from the call-by-call admission control of the PD-FE. In the dynamic case, the bandwidth adjustment is tightly coupled with the admission control.

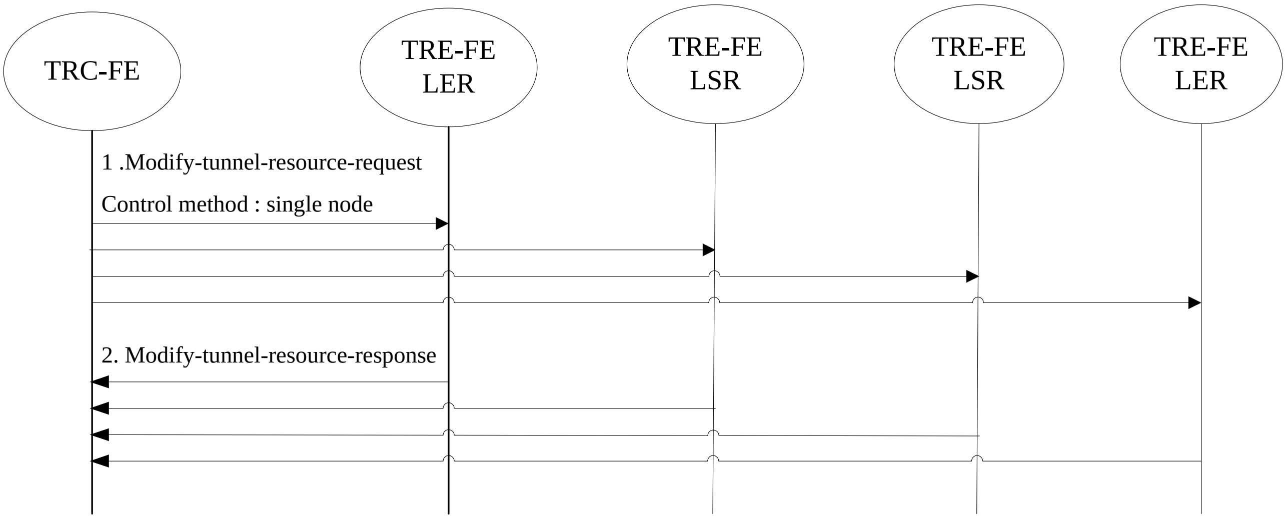

Figure 3 – Aggregate resource control by the TRC-FE

When the tunnel resource is controlled by the TRC-FE, the control procedure is required to be as follows.

1) The TRC-FE identifies the corresponding LERs and LSRs of the LSP and sends the modify-tunnel-resource-request. The control method option is required to be set as 'single node'.

2) Once receiving the request, the recipient LER and LSR change the local bandwidth information of the LSP and send the modify-tunnel-resource-response to the TRC-FE. After receiving the responses from all the corresponding LER and LSR, the TRC-FE completes the tunnel resource modification.

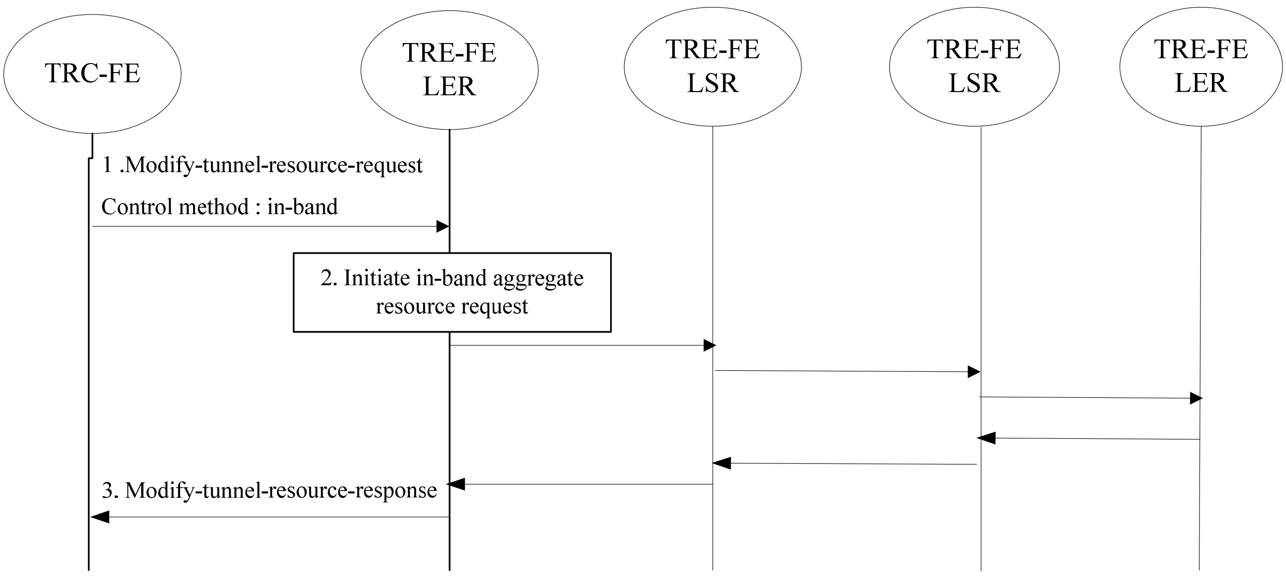

Figure 4 – Aggregate resource control by in-band signalling triggered by the TRC-FE

It is optional that the tunnel resource is modified by in-band signaling capability of the LER or LSR – e.g., as described in [b-IETF RFC 3175] and [b-IETF RFC 4804]. The control procedure is required to be as follows.

1) The TRC-FE initiates the in-band QoS signalling by sending the modify-tunnel-resource-request to the ingress LER. The control method option is required to be set to 'in-band'.

2) Once receiving the request, the recipient LER initiates the in-band signalling to modify the tunnel bandwidth.

3) Once the in-band signalling is completed, the ingress LER sends the modify-tunnel-resource-response to the requesting the TRC-FE.

8 Security considerations

The potential threats and security considerations of the general RACF are defined in [ITU-T Y.2111]. This clause provides additional description of security threats and requirements for the MPLS network controlled by the centralized RACF entity.

– Security between the RACF and the transport function: Secure connection of the Rc and Rn is required to prevent the disclosure, interception, or modification of information.

– Protection from overloading attack: Flooding or the (D)DoS attack to the reference points Rn and Rc is required to be protected. It is recommended that filtering or rate limiting across reference point be used.

– In aggregate resource control with path coupled signalling (e.g., RSVP-TE), it is recommend to consider the security aspects specified in [b-IETF RFC 3209], [b-IETF RFC 4804], and [b-IETF RFC 2702].

Appendix I

End-to-end control scenario in the centralized RACF architecture

(This appendix does not form an integral part of this Recommendation)

MPLS is considered as a good solution in the core network for its traffic engineering capability. Intelligent traffic engineering (TE) schemes are used to achieve the QoS. A managed routing path can be optimally selected for balancing the traffic load and satisfying the multiple QoS constraints. Flows from the access network are aggregated to the pre-provisioned LSP in the core network. Based on the network provider's policy, a network can aggregate the same type of flow into a LSP and a forwarding class. QoS and reliability of the flow are maintained in aggregate level.

In addition to the TE capability, the transport reliability is important in the core network. Any link failure or congestion in the core network causes a more serious problem than in the access network because each network link carries a huge volume of traffic. To support the end-to-end QoS, the reliability and monitoring function should be improved. When a failure happens in a network, the network should be able to redirect the traffic instantaneously. The carrier level OAM capability in the MPLS network is defined in [b-ITU-T Y.1711]. The OAM function in the circuit switching network is mainly for detecting the high BER (bit error rate) or network failure. In the packet switching network, the traffic increment or instantaneous traffic congestion also needs to be monitored by the performance monitoring mechanism. By aggregating flows into the appropriate LSP (label switching path), flow-based QoS and reliability of the traffic can be achieved in the core network.

The call setup procedure needs to be simple in the core network because the number of service request will be very high. It is impractical to control the network devices in every service request. The control procedure should be simplified by utilizing monitoring capability. While traffic condition is not changed dynamically in the core, network status should be constantly monitored to handle the occasional overloaded situation. Based on the network resource status, the service request is selectively accepted according to its service priority. For example, in underload state, the service request is accepted without any limitation. When the network becomes congested, only the service request of the high preference (e.g., emergency traffic) is accepted.

In the core network, the admission control mechanism should be defined in a scaleable manner because of the large number of session requests in the core network. The core network performs reliable traffic delivery and QoS monitoring in aggregate level.

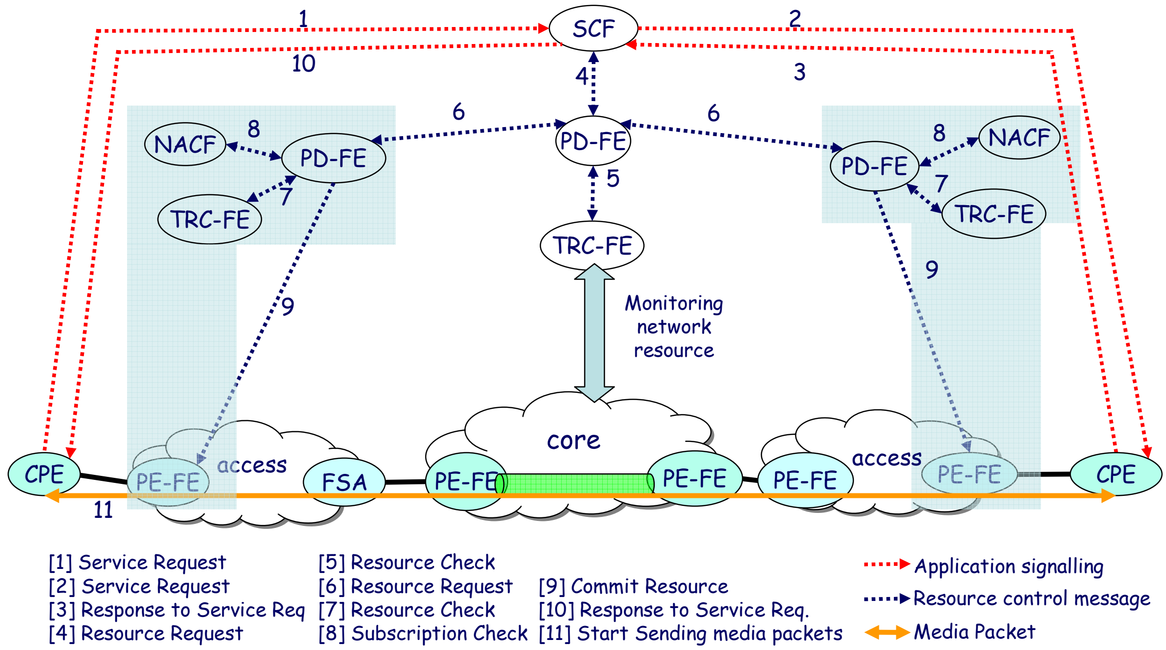

Figure I.1 – End-to-end flow base control procedure in the MPLS core network

Figure I.1 describes the end-to-end control procedure in centralized architecture. The core network is an MPLS-based network. The procedure explains the end-to-end QoS control interaction. The details of the procedure can be explained in the following steps.

(1) A CPE sends the service requests to the call signalling server. If the QoS parameters are not specified in the request, the SCF should determine the QoS parameter.

(2) The SCF identifies the IP address of the terminating CPE and sends the service request. In order to identify the destination address, a proxy call signalling server may be involved.

(3) The terminating CPE response to the service request.

(4) The SCF sends a resource request to the RACF of the core network. The resource request contains the QoS requirement. This figure assumes that the SCF obtained the address information of the destination CPE. When the SCF sends the resource request to the RACF, the source and destination IP addresses are specified in the message.

(5) After receiving the request, the RACF makes an admission decision based on the network operator's policy and resource status.

(6) If the request is acceptable in the core network, the RACF of the core sends a request to the RACF of the access network to check the condition of the access network.

(7) The RACF of the access network checks the resource availability and network policy.

(8) In the access network, the RACF asks the NACF whether the requested QoS exceeds the authorized maximum bandwidth defined in the access network user profile.

(9) Once the results of the policy check, resource check, and subscription check are OK, the RACF of the access network sends the flow level bandwidth information to the edge nodes of the access network.

(10) Once the SCF receives the response of the resource request of step (4), it sends the response to the CPE.

(11) The CPE starts sending the media packets. In the core LSP, the flows are aggregated into a selected LSP. The flow to LSP mapping rule is configured in the PE-FE (or the TRE-FE). The packets can be scheduled in the flow level before being aggregated into the LSP.

One of the main objectives of centralized network architecture is reducing the call admission control complexity in the core network. In the core network, carrier level stability is provided by the MPLS transport. Reliability and monitoring capability are important for this. The control procedure is simplified by minimizing the call-by-call involvement of transport nodes. Based on network resource status, a service request is accepted selectively based on the service priority. The bandwidth of the pre-provisioned LSP is adjusted based on network status.

In step (5), the TRC-FE makes the resource-based admission decision based on the collected resource status. The TRC-FE can interact with the TRE-FE to obtain the LSP related performance parameters. The related performance parameters are defined in [b-IETF RFC 3812], and [b-ITU-T Y.1711].

When the admission request is not acceptable because of a resource shortage, the TRC-FE can trigger a bandwidth adjustment of the congested LSP. The TRC-FE can interact with individual LERs/LSRs to modify the tunnel bandwidth parameters defined in [b-IETF RFC 3812]. The TRC-FE can also request the LER to initiate in-band signalling (e.g., aggregate RSVP-TE defined in [b-IETF RFC 4804]).

Bibliography

[b-ITU-T Y.1711] Recommendation ITU-T Y.1711 (2004), *Operation & maintenance mechanism for MPLS networks*.

[b-IETF RFC 2702] IETF RFC 2702 (1999), *Requirements for Traffic Engineering over MPLS*.

[b-IETF RFC 3175] IETF RFC 3175 (2001), *Aggregation of RSVP for IPv4 and IPv6 Reservations*.

[b-IETF RFC 3209] IETF RFC 3209 (2001), *RSVP-TE: Extensions to RSVP for LSP Tunnels*.

[b-IETF RFC 3812] IETF RFC 3812 (2004), *Multiprotocol Label Switching (MPLS) Traffic Engineering (TE) Management Information Base (MIB)*.

[b-IETF RFC 4804] IETF RFC 4804 (2007), *Aggregation of Resource ReServation Protocol (RSVP) Reservations over MPLS TE/DS-TE Tunnels*.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects and next-generation networks**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2009