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

Future networks

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**Resource control and management function for  
virtual networks for carriers (vRCMF)**

Recommendation ITU-T Y.3014

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## Recommendation ITU-T Y.3014

### Resource control and management function for virtual networks for carriers (vRCMF)

#### Summary

Recommendation ITU-T Y.3014 specifies high-level and functional requirements, architectural framework, and procedures necessary to enhance the performance objective of transport-aware carrier virtual network services, such as joint resource optimization, responsiveness to quickly changing demands, enhanced service resilience via cooperative recovery techniques between service and transport strata, and quality of experience (QoE) enhancement via better use of existing transport and application resources.

#### History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3014	2016-02-13	13	<a href="http://handle.itu.int/11.1002/1000/12711">11.1002/1000/12711</a>

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VNC, vRCMF.

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# Recommendation ITU-T Y.3014

## Resource control and management function for virtual networks for carriers (vRCMF)

### 1 Scope

This Recommendation specifies high-level and functional requirements, the architectural framework, and procedures that enable resource control and management capabilities for virtual network for carriers (VNCs).

The resource control and management function for VNCs (vRCMF):

- deals optimally with highly frequent network changes in the VNC environment;
- supports various customers' policies (e.g., access control, logging, quality of service (QoS), etc.) elastically and dynamically by considering both service and network resources simultaneously;
- supports control and management of virtualized resource: optimal control and management of multi-technology and multi-vendor carriers' virtualized resource.

This Recommendation addresses resource control and management issues in VNCs that represent a network aspect of carrier infrastructure (e.g., virtual networks in data centres and virtualized transport networks).

### 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 Q.3316] Recommendation ITU-T Q.3316 (2016), *Interface and Signalling Requirements and Specification for Cross Stratum Optimization*.
- [ITU-T T.50] Recommendation ITUT T.50 (1992), *International Reference Alphabet (IRA) (Formerly International Alphabet No. 5 or IA5) – Information technology – 7-bit coded character set for information interchange*.
- [ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

### 3 Definitions

#### 3.1 Terms defined elsewhere

None.

#### 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 carrier:** Infrastructure provider that owns the physical network resources and provides network as a service over them to their customers. A virtual network provider is a customer to the carrier.

**3.2.2 customer:** Entity requesting virtual network services. They are provided with an abstract resource view of the network resource to support their users and applications. Customers can be internal or external trusted parties with respect to the provider.

**3.2.3 virtual network provider:** Entity that provides virtual network services to its customers. It typically leases resources from single or multiple carriers' facilities to create virtual network services and offer end-to-end services to their customers.

#### 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CRPFE	Customer Request Processing Functional Element
DNS	Domain Name System
DoS	Denial of Service
DWDM	Dense Wavelength Division Multiplexing
IP	Internet Protocol
MIB	Management Information Base
MPLS-TP	Multiprotocol Label Switching-Transport Profile
NaaS	Network as a Service
OAM	Operation, Administration and Maintenance
OTN	Optical Transport Network
PMFE	Profile Mapping Functional Element
QoE	Quality of Experience
QoS	Quality of Service
SDN	Software-Defined Networking
SRCM	Service Resource Control and Management
SRCM-FE	Service Resource Control and Management-Functional Entity
SRCM GFE	Service Resource Control and Management Gateway Functional Element
TRCM	Transport Resource Control and Management
TRCM-FE	Transport Resource Control and Management-Functional Entity
TRCM GFE	Transport Resource Control and Management Gateway Functional Element
TRMFE	Transport Resource Management Functional Element
TROFE	Transport Resource Optimization Functional Element
TRPFE	Transport Resource Provisioning Functional Element
TRRFE	Transport Resource Repository Functional Element
VM	Virtual Machine
VNC	Virtual Network for Carriers
VPN	Virtual Private Network
vRCMF	Resource Control and Management Function for VNCs
VRMFE	Virtual Resource Management Functional Element

VROFE	Virtual Resource Optimization Functional Element
VRPFE	Virtual Resource Provisioning Functional Element
VTRFE	Virtual Topology Repository Functional Element
WDM	Wavelength Division Multiplexing

## 5 Conventions

None.

## 6 High-level requirements for vRCMF

vRCMF is required to:

- support resource control and management to handle highly frequent network changes in a VNC environment;
- support various customer's policies (e.g., access control, logging, quality of service (QoS)) during the process of its resource control and management;
- reserve resources such that logically isolated resources for each virtual infrastructure environment can be provided;
- control and manage a large number of resources that may be federated among multiple carriers;
- provide virtual service resource lifecycle management;
- provide optimal resource provisioning management;
- support performance management for both service and transport resources in order to enable optimal resource determination;
- support fault management for both service and transport resources in order to enable optimal resource determination;
- optimize resource control and management by coordinating resource status information acquired from both the service and transport stratum.

## 7 Functional requirements for vRCMF

- Secure remote control and management are required by choosing secure protocols.
- vRCMF is required to support the following virtual service resource lifecycle management capabilities:
  - creating an instance of, changing, starting, stopping or rebooting, pausing, unpausing, taking a snapshot, listing snapshots, restoring from a snapshot, removing a snapshot, migration and deletion of a virtual resource;
  - creating, reconfiguring and deleting a virtual network;
  - allocation, backup, restore and release of storage.
- vRCMF is required to support the following logical resource isolation capabilities:
  - allocation of processor, memory and storage resources without any impact on performance among VNCs;
  - allocation of physical link and bandwidth resources without impact on performance among VNCs. This requirement is optional for interworking networks connecting multiple carriers.
- vRCMF is required to support the following service resource control and management (SRCM) capabilities:

- user request processing capabilities;
  - virtual resource optimal estimation capabilities;
  - SRCM gateway capabilities;
  - virtual resource performance and fault status monitoring capabilities.
- vRCMF is required to support the following transport resource control and management (TRCM) capabilities:
- TRCM gateway capabilities;
  - service to transport profile mapping capabilities;
  - transport signalling invocation or software-defined networking (SDN) control-triggering capabilities;
  - transport resource optimal estimation capabilities;
  - transport resource performance and fault status monitoring capabilities.

## 8 Architectural framework for vRCMF

Figure 8-1 shows a service control and management architecture for VNC. Service resource control and management-functional entity (SRCM-FE) and transport resource control and management-functional entity (TRCM-FE) interact with each other via a reference point  $V_t$  [ITU-T Q.3316] in order to address the need for transport-aware virtual network services for carriers.

For the sake of simplicity, carrier service (e.g., cloud-based network as a service (NaaS)), control and resource strata are all lumped together as the carrier service stratum, while the transport stratum represents the underlying transport network that actually carries the application data between users and the resources that offer services among carriers, or within a single carrier, depending on the nature of the application services.

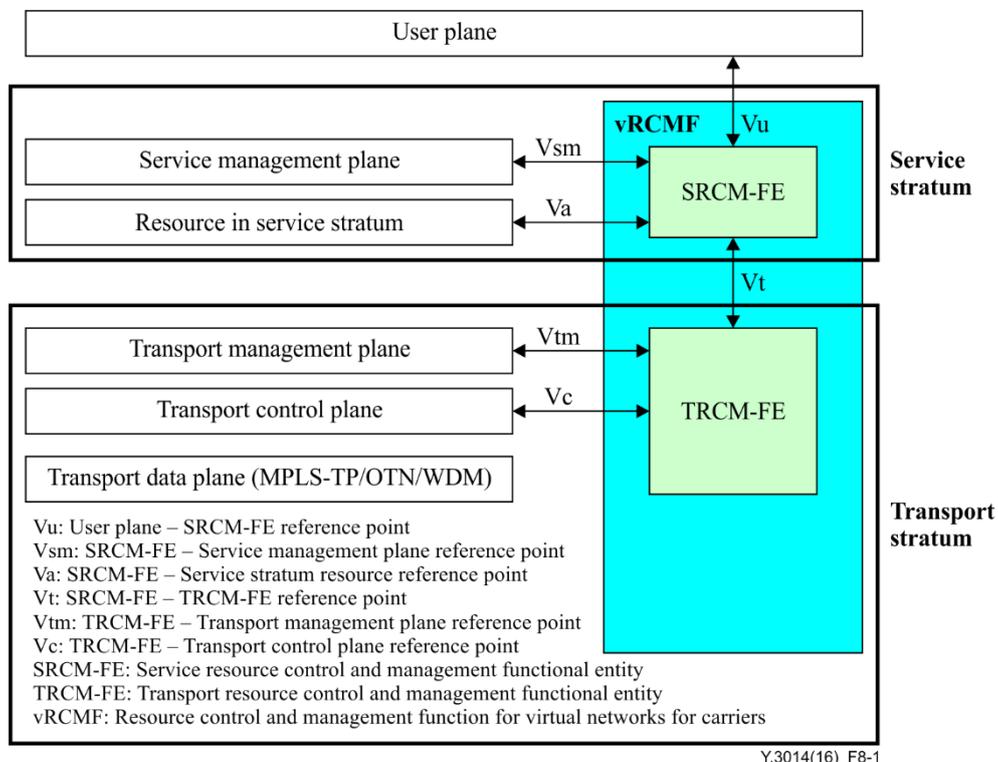


Figure 8-1 – Resource control and management high-level architecture for VNC

The main concept of the architecture in Figure 8-1 is the carrier SCRM-FE interfacing the transport stratum assuming the carrier SRCM-FE is the main control block that has access to all the information in the resource pool.

By creating a reference point between SRCM-FE and TRCM-FE, cross stratum optimization would be enabled. The reference point between the service stratum and the transport stratum can be multiple depending on the arrangement of interworking. That is, one service stratum can interwork with multiple transport strata or a transport stratum interwork with multiple service strata.

The carrier service stratum is concerned with, for example, distributed cloud applications resources that can be roughly categorized into computing resources, i.e., servers of various types and granularities (virtual machines (VMs), memory, disk) and content (video, audio, databases and large data sets).

The transport stratum is multi-layer in nature. It can consist of various combinations of network layers. For example, it can be Internet protocol (IP) over dense wavelength division multiplexing (DWDM), IP over multiprotocol label switching-transport profile (MPLS-TP), IP over optical transport network (OTN)/wavelength division multiplexing (WDM), or pure OTNs such as OTN/DWDM or DWDM. There may be other combinations. The transport stratum has resources that include routers, switches and links, as well as admission control, bandwidth reservation capability and other network related capability. TRCM-FE in the transport stratum is the key entity that interacts with the carrier SRCM-FE to provide intelligent network capability.

The reference point between the carrier service stratum and the transport stratum allows the four main cross stratum optimization opportunities that can enhance the performance objective of transport-aware carrier virtual network services:

- joint resource optimization (service and transport strata);
- responsiveness to quickly changing demands;
- enhanced service resilience (via cooperative recovery techniques between service and transport strata);
- quality of experience (QoE) enhancement (via better use of existing transport and application resources).

The interface allows resource queries from/to the service stratum to/from the transport stratum. It also allows reservation requests from the service stratum to the transport stratum for certain mission-critical applications that demand guaranteed bandwidth reservation with a minimal latency. In addition, the reference point can be used to exchange status data for monitoring, control and management purposes across the strata.

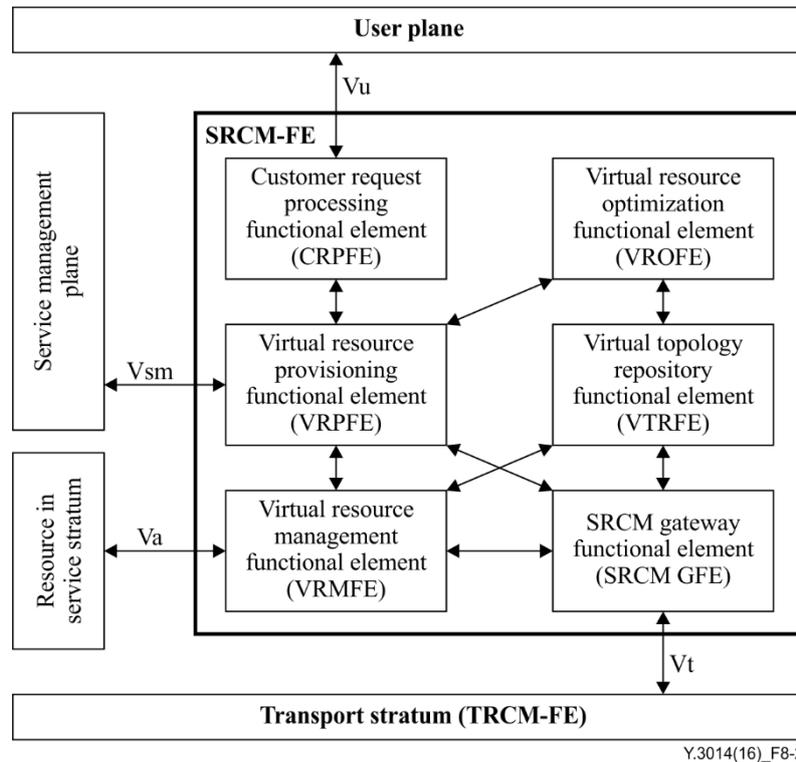
## **8.1 Functional entities**

### **SRCM-FE**

Figure 8-2 specifies SRCM-FE functionality and its relationship with other neighbour functional entities. SRCM-FE consists of a customer request processing functional element (CRPFE), virtual resource provisioning functional element (VRPFE), virtual resource optimization functional element (VROFE), SRCM gateway functional element (SRCM GFE), virtual resource management functional element (VRMFE) and virtual topology repository functional element (VTRFE).

The CRPFE processes customer requests, user profile information, user authentication, authorization and accounting, preferences, and billing information, etc. The VRPFE provides virtual resources in the service stratum upon the customer's request. It also requests associated transport resource provisioning if any via SRCM GFE. VROFE calculates and determines optimal virtual resources to be allocated. They are based on a customer's request and virtual topology collected by the VRMFE and stored in the virtual resource repository.

An SRCM GFE creates a service profile based on the user request and the determined virtual resource availability. It will be conveyed to TRCM-FE for further transport-related processing. It also receives transport resource information sent by TRCM-FE. The VRMFEE monitors status of virtual resources, such as performance and usage of server, VM and storage resources. It also collects fault status information from the virtual resources. The monitored information is used by VROFE for the optimal determination. It is also used by the SRCM GFE to create a service profile.



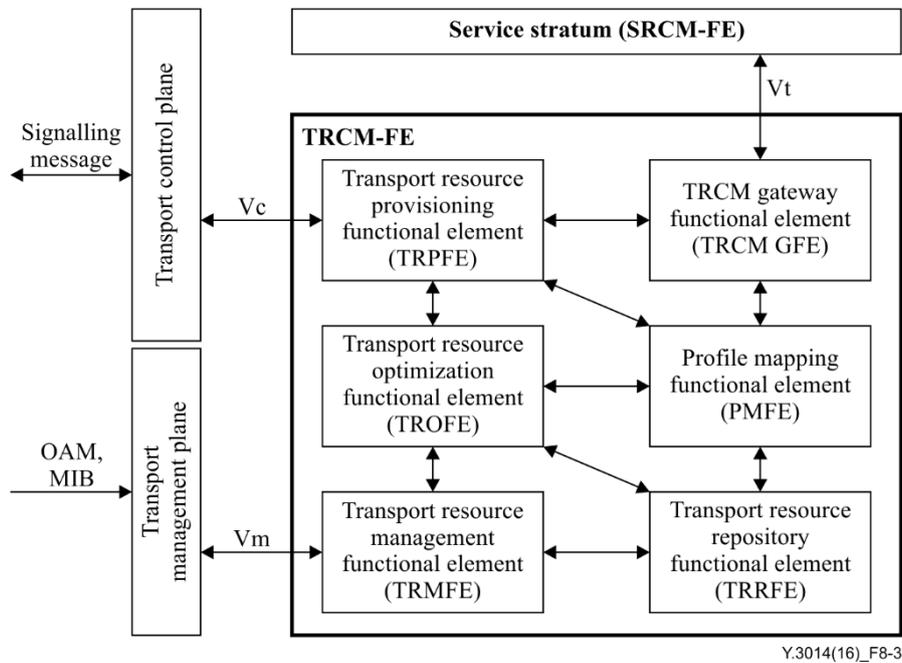
**Figure 8-2 – SRCM-FE functionality and reference points**

### TRCM-FE

Figure 8-3 specifies TRCM-FE functionality and its relationship with other neighbour functional entities. The TRCM-FE consists of a TRCM gateway functional element (TRCM GFE), transport resource provisioning functional element (TRPFE), transport resource optimization functional element (TROFE), profile mapping functional element (PMFE), transport resource repository functional element (TRRFE) and a transport resource management functional element (TRMFEE).

The TRCM GFE receives the service profiles from the SRCM-FE, authenticates, performs admission control, and sends transport resource information to the SRCM-FE. The PMFE maps the service profile into network resources, such as network location, path and addresses. It uses network resource information retrieved from the TRMFEE. It then triggers appropriate transport signalling for the transport resource provisioning. Transport control signalling can be performed either by a SDN-based transport controller or a legacy signalling means. TRCM-FE can use either method depending on the supported capability. If a SDN controller is involved, the TRPFE interacts with the north-bound interface of the transport SDN controller.

The TROFE calculates and determines optimal transport resources based not only on transport resources received from the TRMFEE, but also on the service profile information indirectly extracted from the PMFE. The optimization results are stored by TRRFE and used by TRPFE for the optimal resource provisioning. Finally, the TRMFEE monitors transport resource status information collected from various sources such as operation, administration and maintenance (OAM), signalling, and the management information base (MIB). It performs fault management. It also performs abstraction, virtualization and correlation of the monitored information to be sent to the SRCM-FE.



**Figure 8-3 – TRCM-FE functionality and reference points**

## 9 Reference Points

By default, all information components in an information flow defined in this clause are to be considered mandatory unless they are explicitly identified as being optional.

### 9.1 Reference point Vu

The Vu reference point is required to allow the customer request or response information needed for customer resource reservation to be exchanged between the user plane and service stratum.

The Vu reference point may operate as an intra-domain or an inter-domain reference point.

#### 9.1.1 Functional requirements

##### 9.1.1.1 Resource control and management functional requirements

The Vu reference point provides the ability for the user plane to make requests to the SRCM-FE for:

- resource reservation;
- a status report of resource reservation, if the request was a scheduled request.

##### 9.1.1.2 Resource control and management session processing functional requirements

To ensure the reliability and performance of resource control and management session operations across the Vu reference point, the following capabilities are required.

**overload control:** The Vu reference point is required to provide the capability to support overload control for preventing the overflow of information messages exchanged between user plane and SRCM-FE.

**synchronization and audit:** The Vu reference point is required to provide the capability to support synchronization and audit of the resource control and management session status in support of recovery and operational information statistics and auditing.

**session state maintenance:** The Vu reference point is required to be able to maintain the session state using either soft-state or hard-state approaches.

### 9.1.2 Information exchange requirements

This clause provides a brief description of the information exchange requirements for the Vu reference point.

**request-response transactions:** The reference point is required to allow the user plane to request a transaction to be performed by the SRCM-FE and get a response (that can be correlated with the request) in return.

**notifications:** The reference point is required to support the notification of asynchronous events (from the SRCM-FE to the user plane).

**reliable delivery:** The reference point is required to provide reliable delivery of messages.

**capabilities:** The user plane is required to be able to determine the capabilities of the appropriate SRCM-FE instance when requesting resources and other service stratum functions.

**security:** The Vu is required to support the authentication between the user plane and the SRCM-FE such that requests to the SRCM-FE from unauthenticated sources will not be performed and such that the user plane can verify the source of notifications sent from the SRCM-FE.

**one-to-many and many-to-one:** Two modes are required to be supported: 1) one-to-many mode: a user plane is required to be able to communicate with multiple SRCM-FEs; 2) many-to-one mode: multiple user plane instances are required to be able to make requests to a given SRCM-FE.

### 9.1.3 Information components

The information components exchanged across the Vu reference point are categorized in Table 9-1.

**Table 9-1 – Information components exchanged across the Vu reference point**

<b>Information component</b>	<b>Description</b>
User identifier	A unique identifier for different instances of the user plane within the same administrative domain of a single requestor.
Resource reservation session identifier	An identifier for the session for which the resource reservation requests are sent to the SRCM-FE. The identifier has to be unique within the same user plane instance.
Globally unique IP address information (optional)	A set of IP address information used for locating the user plane network in which the customer is requesting the transport resource.
– Unique IP address	The IP address for identifying the user plane instance.
– Address realm	The addressing domain of the IP address (e.g., subnet prefix or virtual private network (VPN) ID).
Resource requestor identifier	An identifier for the requestor (i.e., the owner of the user plane) of the resource reservation service. It is unique over the requestors sending requests for the resource.
Resource request priority (optional)	The indication of the importance of a resource reservation request. It can be used for processing simultaneous requests by the SRCM-FE based on the priority level.
Reservation holding time (optional)	The value of the time interval for which the resource is reserved.
Resource request result	Indication of the result for a resource request (includes both synchronous and scheduled request result).
EventNotify	Allows the SRCM-FE to send a notification to the user plane for an event that may need the user plane to take appropriate action for the requested resource reservation.

## **9.2 Reference point Vsm**

The Vsm reference point is required to allow customer request or response information needed for user profiling, user authentication/authorization/accounting, and billing, which are associated with a customer's reservation request made by the user plane to be exchanged between the SRCM-FE and the customer service management plane.

The Vsm reference point operates as an intra-domain reference point.

### **9.2.1 Functional requirements**

#### **9.2.1.1 Resource control and management functional requirements**

The Vsm reference point provides the ability for the SRCM-FE to make requests to the service management plane for:

- user profiling;
- user authentication, authorization, and accounting;
- billing.

#### **9.2.1.2 Resource control and management session processing functional requirements**

To ensure the reliability and performance of the resource control and management session operations across the Vsm reference point, the following capabilities are required.

**overload control:** The Vsm reference point is required to provide the capability to support overload control for preventing the overflow of information messages exchanged between SRCM-FE and service management plane.

**synchronization and audit:** The Vsm reference point is required to provide the capability to support synchronization and audit of the resource control and management session status in support of recovery and operational information statistics and auditing.

**session state maintenance:** The Vsm reference point is required to be able to maintain the session state using either soft-state or hard-state approaches.

### 9.2.2 Information exchange requirements

This clause provides a brief description of the information exchange requirements for the Vsm reference point.

**request-response transactions:** The reference point is required to allow the SRCM-FE to request a transaction to be performed by the service management plane and get a response (that can be correlated with the request) in return.

**notifications:** The reference point is required to support the notification of asynchronous events (from the service management plane to the SRCM-FE).

**reliable delivery:** The reference point is required to provide reliable delivery of messages.

**capabilities:** The SRCM-FE is required to be able to determine the capabilities of an appropriate service management plane instance when requesting resources and other service stratum functions.

**security:** The Vsm is required to support the authentication between the SRCM-FE and the service management plane such that requests to the service management plane from unauthenticated sources will not be performed and such that the SRCM-FE can verify the source of notifications sent from the service management plane.

**one-to-many and many-to-one:** Two modes are required to be supported: 1) one-to-many mode: an SRCM-FE is required to be able to communicate with multiple service management planes; 2) many-to-one mode: multiple SRCM-FE instances are required to be able to make requests to a given service management plane.

### 9.2.3 Information components

The information components exchanged across the Vsm reference point are categorized in Table 9-2.

**Table 9-2 – Information components exchanged across the Vsm reference point**

Information component	Description
User identifier	A unique identifier for different instances of the service management plane within the same administrative domain of a single requestor.
Authentication information	Authenticates the peers (i.e., service management plane and SRCM-FE).
Charging correlation information	Charging correlation information, such as the charging ID of the customer and transport networks, and resource usage information.
User profile	Describes a user profile generated by the service management plane for a resource reservation request.
EventNotify	Allows the service management plane to send a notification to the SRCM-FE for an event that may need the SRCM-FE to take appropriate action.

### 9.3 Reference point Va

The Va reference point is required to allow service stratum resource request or response information needed for a customer's service stratum resource collection to be exchanged between the SRCM-FE and the service stratum resource.

The Va reference point may operate as an intra-domain reference point.

#### 9.3.1 Functional requirements

##### 9.3.1.1 Resource control and management functional requirements

The Va reference point provides the ability for the SRCM-FE to make requests for:

- collection of the service stratum compute, storage and network resources;
- the status of the service stratum compute, storage and network resources;
- a status report of the service stratum compute, storage and network resource status information, and events such as resource operational statistics, resource usage and failures.

In addition, the SRCM-FE can request notification of scheduled events.

##### 9.3.1.2 Resource control and management session processing functional requirements

To ensure the reliability and performance of resource control and management session operations across the Va reference point, the following capabilities are required:

**overload control:** The Va reference point is required to provide the capability to support overload control for preventing the overflow of information messages exchanged between SRCM-FE and service stratum resource.

**synchronization and audit:** The Va reference point is required to provide the capability to support synchronization and audit of the resource control and management session status in support of recovery and operational information statistics and auditing.

**session state maintenance:** The Va reference point is required to be able to maintain the session state using either soft-state or hard-state approaches.

#### 9.3.2 Information exchange requirements

This clause provides a brief description of the information exchange requirements for the Va reference point.

**request-response transactions:** The reference point is required to allow the SRCM-FE to request a transaction to be performed by the service stratum resource and get a response (that can be correlated with the request) in return.

**notifications:** The reference point is required to support the notification of asynchronous events (from the service stratum resource to the SRCM-FE).

**reliable delivery:** The reference point is required to provide reliable delivery of messages.

**capabilities:** The SRCM-FE is required to be able to determine the capabilities of an appropriate service stratum resource instance when requesting resources and other transport plane functions.

**security:** The Va is required to support the authentication between the SRCM-FE and the service stratum resource such that requests to the service stratum resources from unauthenticated sources will not be performed and such that the SRCM-FE can verify the source of notifications sent from the service stratum resources.

**one-to-many and many-to-one:** Two modes are required to be supported: 1) one-to-many mode: a SRCM-FE is required to be able to communicate with multiple service stratum resources; 2) many-to-one mode: multiple SRCM-FE instances are required to be able to make requests to a given service stratum resource.

### 9.3.3 Information components

The information components exchanged across the Va reference point are categorized in Table 9-3.

**Table 9-3 – Information components exchanged across the Va reference point**

Information component	Description
User identifier	A unique identifier for different instances of the compute, storage or network resource within the same administrative domain of a single requestor.
Authentication information	Authenticates the peers (i.e., compute, storage or network resources and the SRCM-FE).
Service stratum resource profile identifier	A unique compute, storage or network resource profile identifier required for a resource reservation request.
Service stratum resource profile	Describes compute, storage, or network resource profile information required for a resource reservation request.
EventNotify	Allows the compute, storage or network resource to send a notification to the SRCM-FE for an event that may need the SRCM-FE to take appropriate action.

## 9.4 Reference point Vt

The Vt reference point is required to allow resource request or response information needed for optimal resource control and management for VNC to be exchanged between the service and transport stratum. It is also required to allow exchanging status data for monitoring, control, and management purposes.

### 9.4.1 Functional requirements

#### 9.4.1.1 Resource control and management functional requirements

The Vt reference point provides the ability for the SRCM-FE to make requests for:

- resource status in the transport stratum;
- resource reservation for a path in the transport stratum;
- QoS handling;
- priority handling;
- a status report of network status information and events such as traffic statistics, resource usage and connection failure.

In addition, the SRCM-FE can request notification of scheduled events.

#### 9.4.1.2 Resource control and management session processing functional requirements

To ensure the reliability and performance of resource control and management session operations across the Vt reference point, the following capabilities are required:

**overload control:** The Vt reference point is required to provide the capability to support overload control for preventing the overflow of information messages exchanged between the SRCM-FE and TRCM-FE.

**synchronization and audit:** The Vt reference point is required to provide the capability to support synchronization and audit of the resource control and management session status in support of recovery and operational information statistics and auditing.

**session state maintenance:** The Vt reference point is required to be able to maintain the session state using either soft-state or hard-state approaches.

## 9.4.2 Information exchange requirements

This clause provides a brief description of the information exchange requirements for the Vt reference point.

**request-response transactions:** The reference point is required to allow the SRCM-FE to request a transaction to be performed by the TRCM-FE and get a response (that can be correlated with the request) in return.

**notifications:** The reference point is required to support the notification of asynchronous events (from the TRCM-FE to the SRCM-FE).

**reliable delivery:** The reference point is required to provide reliable delivery of messages.

**capabilities:** The SRCM-FE is required to be able to determine the capabilities of an appropriate TRCM-FE instance when requesting resources and other transport plane functions.

**security:** The Vt is required to support the authentication between the SRCM-FE and the TRCM-FE such that requests to the TRCM-FE from unauthenticated sources will not be performed and such that the SRCM-FE can verify the source of notifications sent from the TRCM-FE.

**one-to-many and many-to-one:** Two modes are required to be supported: 1) one-to-many mode: a SRCM-FE is required to be able to communicate with multiple TRCM-FEs; 2) many-to-one mode: multiple SRCM-FE instances are required to be able to make requests to a given TRCM-FE.

## 9.4.3 Information components

The information components exchanged across the Vt reference point are categorized in 9.4.3.1.

### 9.4.3.1 Resource control processing information components

The information components for resource control and management request processing are described in Table 9-4.

**Table 9-4 – Information components for resource control and management request processing**

Information component	Description
Connection ID	Identifies a transport connection or path. A unique value for the connection ID is set by the TRCM-FE. Two types supported are IPv4 and IPv6 transport connection IDs.
Authentication information	Authenticates the peers (i.e., TRCM-FE and SRCM-FE).
Reason code	Specifies the reason associated with a particular connection ID or service ID.
Identity identification	Specifies unique identification. It adopts only the International Alphabet No. 5 string format defined in [ITU-T T.50]. Generally, it is a static IP address of the SRCM-FE or TRCM-FE. When the SRCM-FE or TRCM-FE adopts a dynamic IP address, an identity identification object can use the domain name system (DNS) name.
Keep-alive timer	Specifies the maximum time interval over which a Vt protocol transport channel message is recommended in order to be sent or received.
Data consistency information	Verifies the consistency of the Vt protocol message.
Service ID	Identifies a service and a unique value should be set for each service by the SRCM-FE.

**Table 9-4 – Information components for resource control and management request processing**

Information component	Description
Service profile	Describes a service profile generated by the SRCM-FE for a service request.
Connection profile	Describes a connection that can be set up or has already been set up by the TRCM-FE.
EventNotify	Allows the TRCM-FE send notification to the SRCM-FE for an event that may need the SRCM-FE take appropriate action.
Service attribute object	Describes the attributes associated with the service profile. It is a sub-object of the service profile object.
Constraint object	Describes the constraint imposed by a service. It is a sub-object of the service profile object.
Connection attribute object	Describes the attributes associated with the transport connection. It is a sub-object of the connection profile object.

## 9.5 Reference point Vtm

The Vtm reference point is required to allow transport resource request or response information needed for collecting transport resource to be exchanged between the TRCM-FE and transport management plane.

The Vtm reference point may operate as an intra-domain reference point.

### 9.5.1 Functional requirements

#### 9.5.1.1 Resource control and management functional requirements

The Vtm reference point provides the ability for the TRCM-FE to make requests for:

- the collection of information from the transport resource;
- the status of the transport resource;
- a status report of transport resource status information and events such as transport resource operation statistics, resource usage and failures.

In addition, the TRCM-FE can request notification of scheduled events.

#### 9.5.1.2 Resource control and management session processing functional requirements

To ensure the reliability and performance of resource control and management session operations across the Vtm reference point, the following capabilities are required:

**overload control:** The Vtm reference point is required to provide the capability to support overload control for preventing the overflow of information messages exchanged between transport management plane and the TRCM-FE.

**synchronization and audit:** The Vtm reference point is required to provide the capability to support synchronization and audit of the resource control and management session status in support of recovery and operational information statistics and auditing.

**session state maintenance:** The Vtm reference point is required to be able to maintain the session state using either soft-state or hard-state approaches.

### 9.5.2 Information exchange requirements

This clause provides a brief description of the information exchange requirements for the Vtm reference point.

**request-response transactions:** The reference point is required to allow the TRCM-FE to request a transaction to be performed by the transport management plane and get a response (that can be correlated with the request) in return.

**notifications:** The reference point is required to support the notification of asynchronous events (from the transport management plane to the TRCM-FE).

**reliable delivery:** The reference point is required to provide reliable delivery of messages.

**capabilities:** The TRCM-FE is required to be able to determine the capabilities of an appropriate transport management plane instance when requesting resources and other transport plane functions.

**security:** The Vtm is required to support the authentication between the TRCM-FE and the transport management plane such that requests to the transport management plane from unauthenticated sources will not be performed and such that the TRCM-FE can verify the source of notifications sent from the transport management plane.

**one-to-many and many-to-one:** Two modes are required to be supported: 1) one-to-many mode: a TRCM-FE is required to be able to communicate with multiple transport management planes; 2) many-to-one mode: multiple TRCM-FE instances are required to be able to make requests to a given transport management plane.

### 9.5.3 Information components

The information components exchanged across the Vtm reference point are categorized in Table 9-5.

**Table 9-5 – Information components exchanged across the Vtm reference point**

Information component	Description
User identifier	A unique identifier for different instances of the transport management plane within the same administrative domain of a single requestor.
Authentication information	Authenticates the peers (i.e., the transport management plane and the TRCM-FE).
Transport resource profile identifier	A unique transport resource profile identifier required for a resource reservation request.
Transport resource profile	Describes transport resource profile information required for a resource reservation request.
EventNotify	Allows the transport management plane to send notification to the TRCM-FE for an event that may need the TRCM-FE to take appropriate action.

### 9.6 Reference point Vc

The Vc reference point is required to allow transport resource control request or response information needed for controlling transport resources to be exchanged between the TRCM-FE and the transport control plane.

The Vc reference point may operate as an intra-domain reference point.

## 9.6.1 Functional requirements

### 9.6.1.1 Resource control and management functional requirements

The Vc reference point provides the ability for the TRCM-FE to make requests for:

- resource reservation for a path in the transport stratum;
- QoS handling;
- priority handling;
- a status report of a network status information and events such as traffic statistics, resource usage and connection failure.

In addition, the TRCM-FE can request notification of scheduled events.

### 9.6.1.2 Resource control and management session processing functional requirements

To ensure the reliability and performance of resource control and management session operations across the Vc reference point, the following capabilities are required:

**overload control:** The Vc reference point is required to provide the capability to support overload control for preventing the overflow of information messages exchanged between TRCM-FE and transport control plane.

**synchronization and audit:** The Vc reference point is required to provide the capability to support synchronization and audit of the resource control and management session status in support of recovery and operational information statistics and auditing.

**session state maintenance:** The Vc reference point is required to be able to maintain the session state using either soft-state or hard-state approaches.

## 9.6.2 Information exchange requirements

This clause provides a brief description of the information exchange requirements for the Vc reference point.

**request-response transactions:** The reference point is required to allow the TRCM-FE to request a transaction to be performed by the transport control plane and get a response (that can be correlated with the request) in return.

**notifications:** The reference point is required to support the notification of asynchronous events (from the transport control plane to the TRCM-FE).

**reliable delivery:** The reference point is required to provide reliable delivery of messages.

**capabilities:** The TRCM-FE is required to be able to determine the capabilities of an appropriate transport control plane instance when requesting resources and other transport plane functions.

**security:** The Vc is required to support the authentication between the TRCM-FE and the transport control plane such that requests to the transport control plane from unauthenticated sources will not be performed and such that the TRCM-FE can verify the source of notifications sent from the transport control plane.

**one-to-many and many-to-one:** Two modes are required to be supported: 1) one-to-many mode: a TRCM-FE is required to be able to communicate with multiple transport control planes; 2) many-to-one mode: multiple TRCM-FE instances are required to be able to make requests to a given transport control plane.

### 9.6.3 Information components

The information components exchanged across the Vc reference point are categorized in Table 9-6.

**Table 9-6 – Information components exchanged across the Vc reference point**

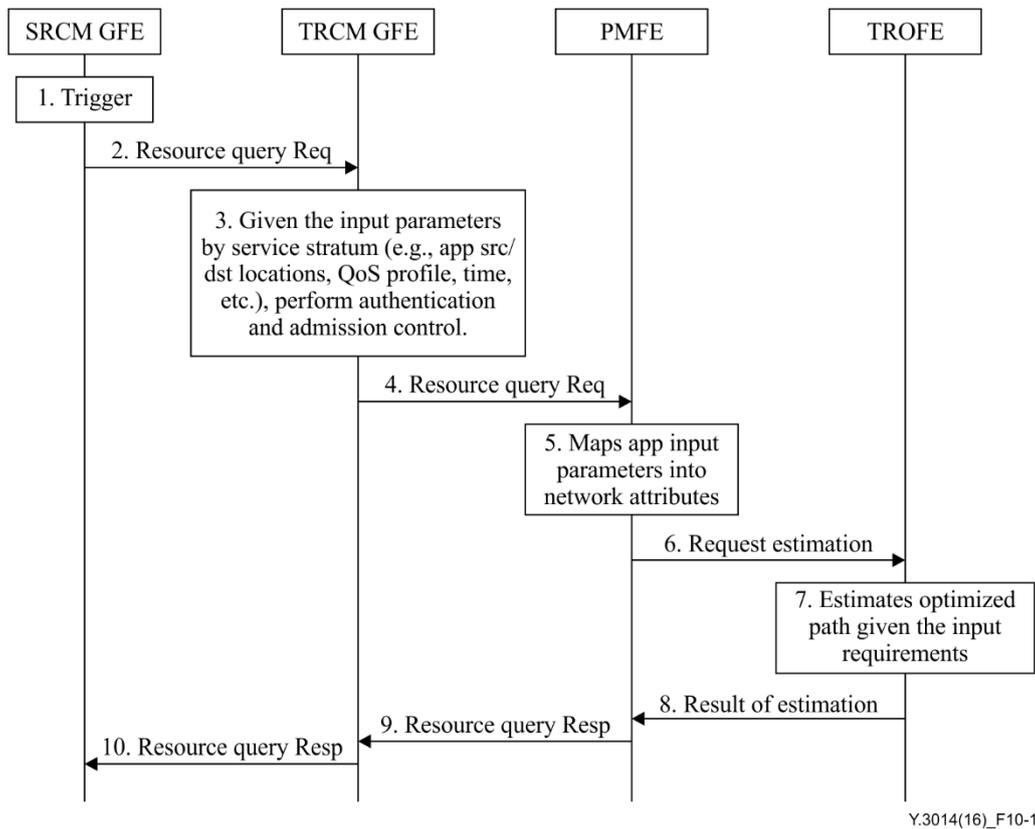
<b>Information component</b>	<b>Description</b>
User identifier	A unique identifier for different instances of the transport control plane within the same administrative domain of a single requestor.
Resource reservation session identifier	An identifier for the session for which the resource reservation requests are sent to the transport control plane. The identifier has to be unique within the same transport plane instance.
Globally unique IP address information (optional)	A set of IP address information used for locating the network in which the TRCM-FE is requesting the transport resource.
– Unique IP address	The IP address for identifying TRCM-FE.
– Address realm	The addressing domain of the IP address (e.g., subnet prefix or VPN ID).
Resource requestor identifier	An identifier for the requestor (i.e., the owner of TRCM-FE) of the resource reservation service. It is uniquely differentiated among the requestors sending requests for the transport resource.
Resource request priority (optional)	The indication of the importance of a resource reservation request. It can be used for processing simultaneous requests by the transport control plane based on the priority level.
Reservation holding time (optional)	The value of time interval for which the resource is reserved.
Resource request result	Indication of the result for a resource request (includes both synchronous and scheduled request result).
EventNotify	Allows the transport control plane to send a notification to the TRCM-FE for an event that may need to take appropriate action for requested resource reservation.

## 10 Procedures

This clause defines basic procedures triggered by a single event (e.g., a resource query). These basic procedures could be further composed into any possible composite procedures triggered by a series of events.

### 10.1 Procedures for resource information collection

In order to support resource optimization between a service stratum and a transport stratum, the service stratum requires abstracted resource information from the underlying transport stratum. The resource query procedure can be used to collect such information. See Figure 10-1.

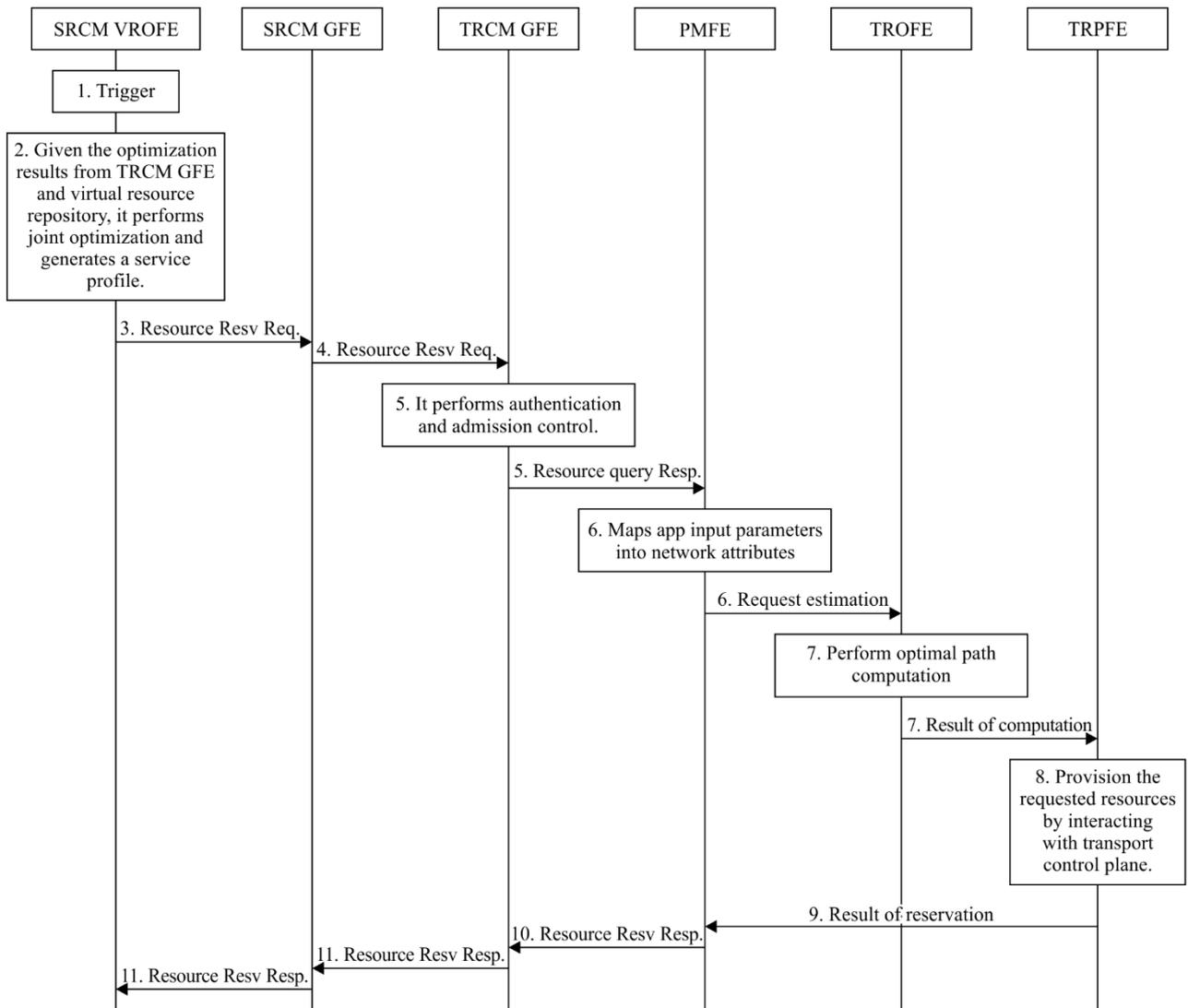


**Figure 10-1 – Service stratum-initiated resource query procedure**

1. A resource query request is triggered by applications of a transport service request. The application service request is then processed by the service stratum and conveyed to the transport stratum to collect the required resources to perform resource optimization.
2. The SRCM GFE sends a transport resource query message to the TRCM GFE in the TRCM-FE. The message may contain a set of application's source and destination locations, QoS profile such as bandwidth, maximum latency and maximum jitter, and time interval for scheduling.
3. The TRCM GFE performs the authentication and admission control on the message.
4. The TRCM GFE then forwards it to the PMFE.
5. The PMFE maps the set of application input parameters into the transport specific attributes.
6. The PMFE requests estimation of the optimization.
7. The TROFE makes an estimate based on the mapped attributes information.
8. The estimation result is forwarded to the PMFE.
9. The PMFE generates the query response message carrying the estimation result and sends it to the TRCM GFE.
10. The TRCM GFE forwards the query response message to the SRCM GFE. The SRCM-FE then stores the estimation result in the virtual topology repository VTRFE for joint optimization.

## 10.2 Procedures for resource reservation

The service stratum can request resource reservation in the transport stratum for application service deployment. Such procedure may be triggered by different application events, e.g., QoS-guaranteed network path provisioning, bulk VM migration and backup or restoration of storage. See Figure 10-2.



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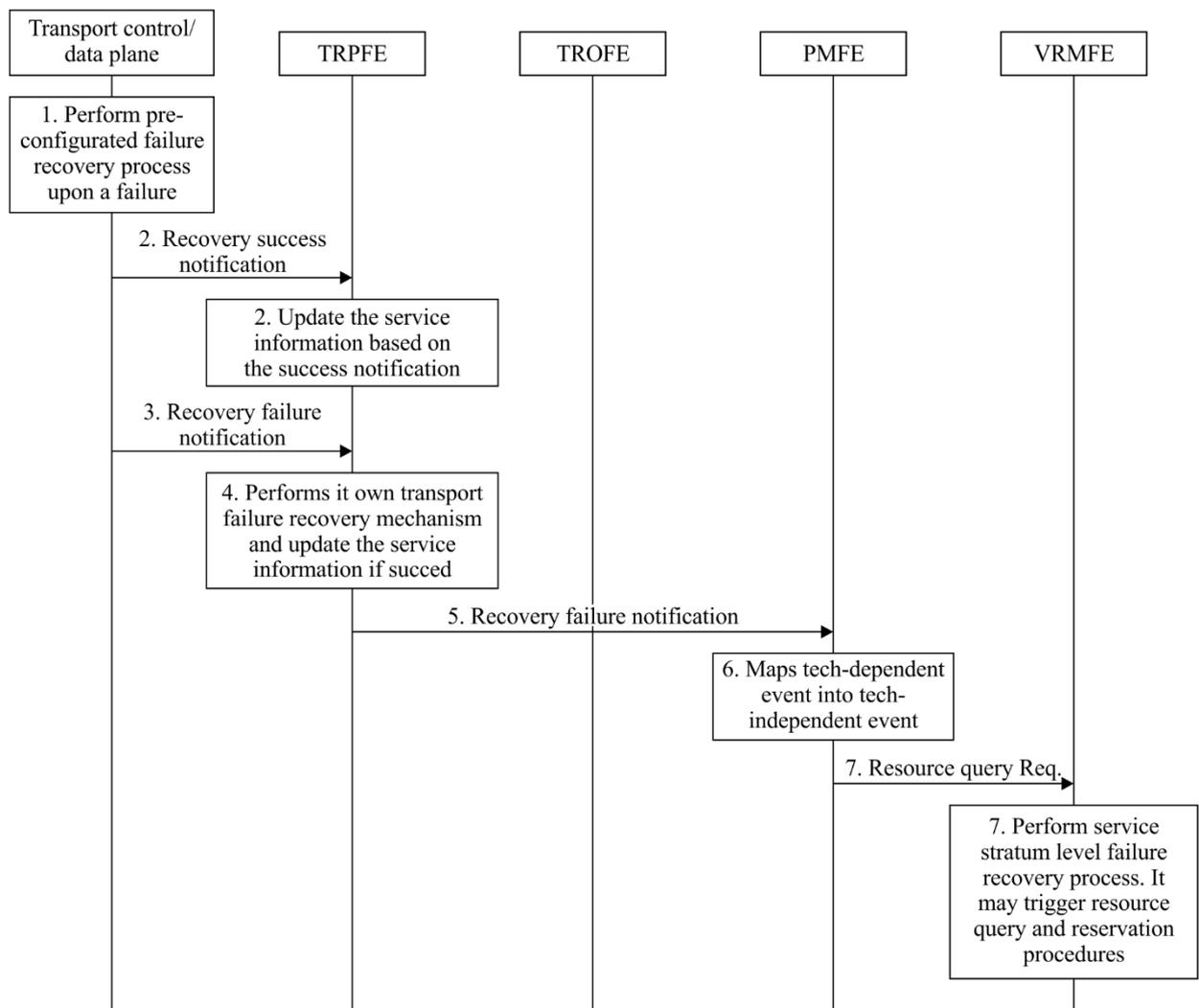
**Figure 10-2 – Resource reservation procedure**

1. A resource reservation request is triggered by applications of the transport service request. The application service request is then processed by the service stratum and conveyed to the transport stratum for provisioning required resources with the given input requirements.
2. The VROFE in the service stratum performs joint optimization based on the estimation results received from the TRCM-FE and virtual resource status stored in the virtual topology repository and determines the optimal way to fulfil the application requirements.
3. The VROFE sends the service profile to the SRCM GFE, which indicates the characteristics of the application from a network perspective and the QoS requirements that the application will require from the network.
4. The SRCM GFE sends a resource reservation request message carrying the service profile to the TRCM GFE.
5. The TRCM GFE performs the authentication and admission control on the message and then forwards it to the PMFE.
6. The PMFE maps the service profile into technology-dependent network resources requirements. The output of mapping is forwarded to the TROFE.
7. The TROFE performs the optimal path computation based on the transport resources received from the TRMFE, and sends the path computation result to the TRPFE.

8. For unscheduled transport services, the TRPFEE triggers the transport control plane via the Vc interface to start the signalling for the connection set-up in the transport data plane immediately after the previous step is completed. For scheduled transport services, the TRPFEE will wait for the requested time interval. In this case, a re-optimization process may be applied if needed. The transport control plane responds to the TRPFEE with the result of the connection set-up. If the connection set-up is successful, the TRCM-FE requests the TRRRE to update the status of transport resource in the transport resource repository.
9. The TRPFEE returns the connection set-up result to PMFE.
10. The PMFE generates the resource reservation response message carrying the connection set-up result and forwards it to the TRCM GFE.
11. TRCM GFE sends the resource reservation result back to the SCRM VROFE via the SRCM GFE.

### 10.3 Procedures for resource failure recovery

Application services may suffer from network level failures (e.g., link failure, resource outage) or service level failures (e.g., server failure). In such cases, recovery procedures need to take place in both a network stratum and a service stratum. See Figure 10-3.



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**Figure 10-3 – Transport resource failure recovery procedure**

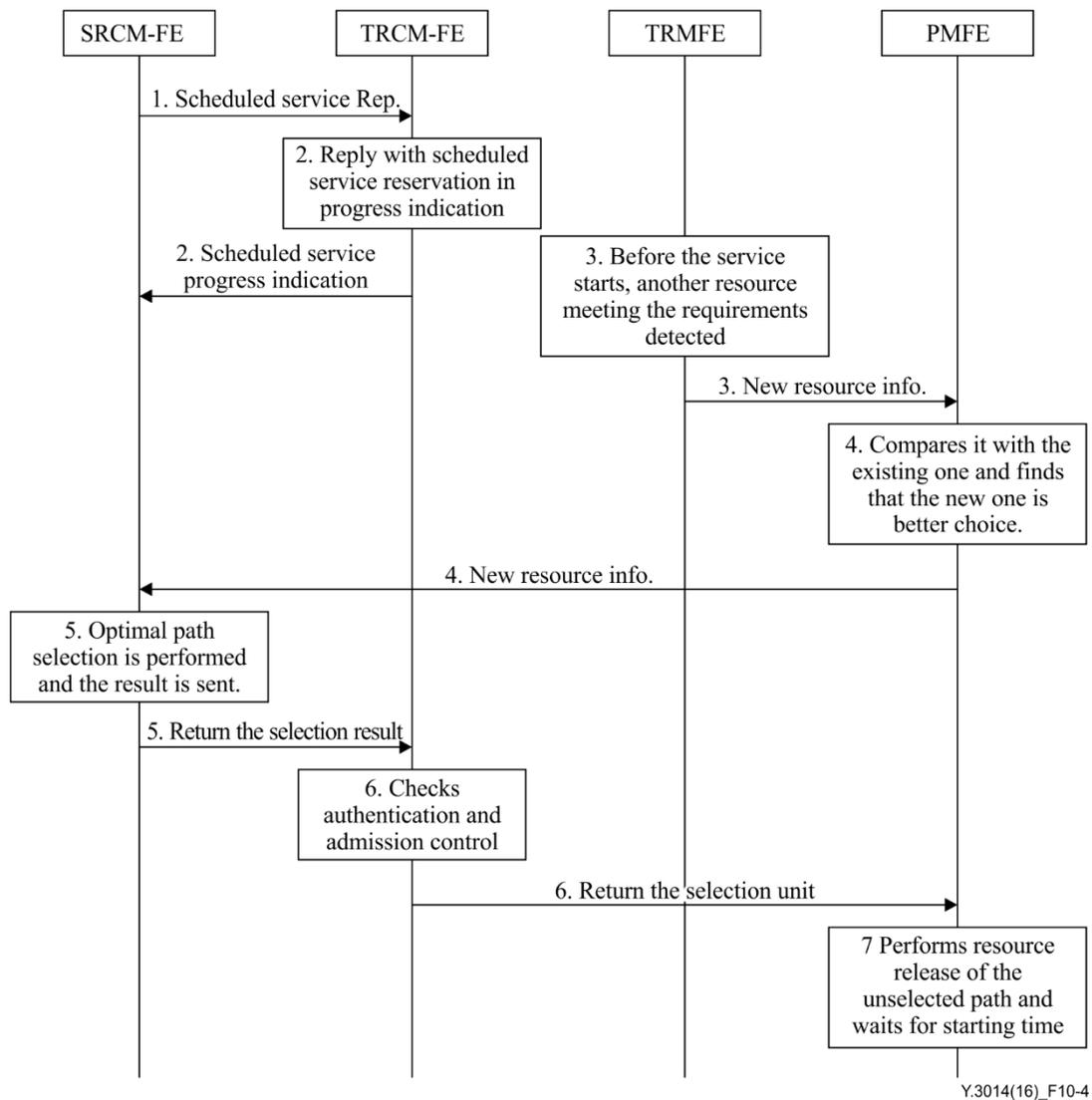
In the case of a transport level failure, procedures are as follows.

1. The transport control plane and transport data plane will perform the transport failure recovery procedures upon the failure if the transport data plane recovery mechanism has been pre-configured.
2. Upon successful recovery, the transport control plane will report the transport failure recovery success event to the TRPFE. Then, the TRPFE can update the service information, including the current transport recovery status and the current working path associated with the application service.
3. If no recovery mechanisms are pre-configured or if the transport control plane and transport data plane failure recovery procedures fail, the transport control plane will report the transport recovery failure to the TRPFE.
4. Upon receiving the transport recovery failure event, the TRPFE performs its own failure recovery process (e.g., dynamic rerouting with a newly provisioned back-up path computed by the TROFE).
5. If dynamic rerouting fails or if there are no other transport failure recovery mechanisms, the TRPFE will notify the failure to the PMFE.
6. The PMFE then maps the technology-dependent transport failure event into a technology-independent service event and sends it to the SRCM-FE via the TRCM GFE.
7. Upon receipt of the service event by the SRCM GFE, the VRMFE can perform the service stratum level failure recovery process (e.g., selecting alternative application servers in a remote location to continue the intended service). Joint optimization can again be performed to choose the optimal destination application server. Also a new transport resource will be reserved for the new destination.

In the case of a service level failure, the SRCM-FE will try to find alternative servers in the same host location. If alternative servers are only available in remote locations, then the SRCM-FE will perform the joint optimization computation to choose the optimal destination server and transport resource to the new destination will be reserved.

#### **10.4 Procedures for event notification**

During the time of a scheduled service request acceptance and actual service activation, network resource status may change. For the optimal resource computation, such status changes have to be notified somehow and it can be done by event notification procedures which are described in Figure 10-4.



**Figure 10-4 – Event notification procedure**

1. The SRCM-FE sends a scheduled service request with a service holding time interval to the TRCM-FE.
2. Upon receiving the request, the TRCM-FE will check the availability of the transport resources to find a path that satisfies the requirement and then sends a reply message while reserving the corresponding resources on the path immediately.
3. Before the scheduled service starts, another eligible path may be detected by the TRMFEE that could also satisfy the service requirements and the result is sent to the PMFE for comparison with the existing one.
4. The PMFE may find that it is a better path to carry the scheduled service and thus sends this new path to the SRCM GFE.
5. The SRCM GFE receives the message from the TRCM-FE and determines an optimal path. Then, a message with the selection result is sent back to the TRCM-FE to avoid unnecessary resource reservation by releasing the unselected path.
6. Upon receiving the selected path, TRCM-FE performs the authentication and admission control on the message and then forwards it to the PMFE.
7. The PMFE carries out the corresponding resource release and waits until the scheduled starting time arrives. Also the scheduled service resource re-optimization may repeat until the service starting time arrives.

Note that there might be multiple event notifications for a certain scheduled service. The scheduled service event notification may occur repeatedly until the scheduled service starts. The same event notification procedures described above apply in that case.

## **11 Security considerations**

This clause describes security threats and potential attacks and defines security requirements for a vRCMF. The security requirements are based on [ITU-T Y.2701]. These considerations are relevant only insofar as the reference points in vRCMF are concerned.

The type of generic threats and their applicability to vRCMF are as described in clauses 11.1 to 11.5.

**11.1 Destruction of information:** This threat refers to the deletion of information pertaining to vRCMF operations, such as transaction state information, resource usage information, accounting information, topology information or policy rules. An example of potential consequences is when the information about the existence (or availability) of a particular resource has been destroyed, the resource effectively becomes unavailable.

**11.2 Corruption or modification of information:** This threat has three aspects:

- 1) corruption of the recorded resource information (or policy rules) so that such data are rendered meaningless or unusable;
- 2) undetected modification of the recorded resource information or policy rules so that such data appear to be meaningful. This can result in theft of service, degradation of service, loss of service, fraudulent accounting or any combination of the above;
- 3) corruption or modification of a signalling message, with the same results as above.

**11.3 Theft, removal or loss of information:** This threat refers to the theft or loss of recorded resource information. It may result in:

- 1) violation of a subscriber's privacy (in case of theft of subscriber information);
- 2) theft of service; and
- 3) degradation, interruption and, ultimately, unavailability of service (in the case of the loss of information).

**11.4 Disclosure of information:** This can occur because of the interception of the signalling messages or because access is granted to an illegitimate user. The consequence is the same as in the case of theft, removal or loss of information (See clause 11.3).

**11.5 Interruption of services:** This threat is typically realized through a denial of service (DoS) attack. Such attacks can make the vRCMF partially or totally unavailable.

The major security requirements for vRCMF are:

- 1) taking into the above security threats into account and supporting measures to counter relevant attacks;
- 2) protection of the signalling exchange in support of resource requests and responses;
- 3) protection of the information contained in all VNC entities involved in this exchange;
- 4) ensuring the availability and overall expected performance of the VNC;
- 5) prevention of illegitimate access to VNC.





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