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SERIES X: DATA NETWORKS, OPEN SYSTEM COMMUNICATIONS AND SECURITY

OSI networking and system aspects – Networking

Managed P2P communications: Overlay resource control protocol (ORCP)

Recommendation ITU-T X.609.2

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Recommendation ITU-T X.609.2

Managed P2P communications: Overlay resource control protocol (ORCP)

Summary

Recommendation ITU-T X.609.2 specifies the overlay resource control protocol (ORCP) that runs on the interface between a cache server/relay server (CS/RS) and an overlay management server (OMS), and on the interface between an OMS and a peer. The ORCP is used to reserve resources and to control the use of a CS and RS. Recommendation ITU-T X.609.2 provides the requirements, protocol operations and message formats used in each operation of the ORCP.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T X.609.2	2016-08-29	11	11.1002/1000/13011

Keywords

CS, managed P2P, ORCP, peer-to-peer, RS.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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NOTE

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As of the date of approval of this Recommendation, ITU had 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/.

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Managed P2P communications: Overlay resource control protocol (ORCP)

1 Scope

This Recommendation specifies the overlay resource control protocol (ORCP) to be used by a cache server (CS), relay server (RS), peer and overlay management server (OMS) in the managed peer-to-peer (MP2P) network. The purpose of the ORCP is to control the resources of overlay networks.

The scope of this Recommendation is:

– requirements for the ORCP based on [ITU-T X.609].

– operation of the ORCP.

– message and parameters used in the ORCP.

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 X.609] Recommendation ITU-T X.609 (2015), *Managed peer-to-peer (P2P) Communications: Functional architecture*.

[IETF RFC 7231] IETF RFC 7231 (2014), *Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 functional entity [b-ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.1.2 fragment [ITU-T X.609]: A piece of shared content.

3.1.3 leech; leecher [b-ITU-T X.609.1]: A peer possessing none or some of fragments composing the content shared among peers participating in the same overlay network. A leech can upload its fragments to other peers and it can also download fragments from other peers.

3.1.4 managed peer-to-peer [b-ISO/IEC TR 20002]: P2P with manageability features to manage the P2P-based service and P2P network by the P2P participants such as P2P service provider, ISP, and peer.

3.1.5 overlay network [b-ITU-T X.1162]: An overlay network is a virtual network that runs on top of another network. Like any other network, the overlay network comprises a set of nodes and links between them. Because the links are logical ones, they may correspond to many physical links of the underlying network.

3.1.6 peer [b-ITU-T X.1161]: Communication node on P2P network that functions simultaneously as both "client" and "server" to the other nodes on the network.

3.1.7 peer-to-peer (P2P) [b-ITU-T Y.2206]: A system is considered to be P2P if the nodes of the system share their resources in order to provide the service the system supports. The nodes in the system both provide services to other nodes and request services from other nodes.

NOTE – Peer is the node in a P2P system.

3.1.8 reference point [b-ITU-T Y.2012]: A conceptual point at the conjunction of two non-overlapping functional entities that can be used to identify the type of information passing between these functional entities.

3.1.9 seed; seeder [b-ITU-T X.609.1]: A peer possessing all fragments composing the content shared among peers participating in the same overlay network. A seed can upload fragments to other peers, but it does not download any fragment.

3.2 Terms defined in this Recommendation

This Recommendation uses the following terms:

3.2.1 cache server (CS): A dedicated server caching whole or parts of contents to achieve a certain purpose in a managed peer-to-peer (MP2P) network. A cache server can have one or more virtual peers.

3.2.2 overlay resource: A dedicated resource to an overlay network for enhancing performance and stability of the overlay network. This includes virtual peers of a cache server and relay instances of relay server.

3.2.3 relay instance: An instance relaying traffic that is running on a relay server. A relay instance conducts traffic relay for a specific peer behind network address translation/firewall (NAT/FW). Every relay instance running on a relay server is uniquely identified.

3.2.4 relay server: A dedicated server relaying traffic from/to peers behind network address translation/firewall (NAT/FW) in a managed peer-to-peer (MP2P) network. A relay server can have one or more relay instances.

3.2.5 virtual peer: An instance acting as a peer running on a cache server. A virtual peer, acting as a peer, joins one or more overlay networks and exchanges fragments with other peers. Virtual peers running on a cache server are uniquely identified.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations:

CS	Cache Server
CSRM	Cache Server Resource Management
DD	Data Delivery
FE	Functional Entity
FQDN	Fully Qualified Domain Name
HTTP	Hypertext Transfer Protocol
ID	Identifier
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
ISP	Internet Service Provider

IXS	Index Server
JSON	JavaScript Object Notation
MP2P	Managed Peer-to-Peer
NAT/FW	Network Address Translation/Firewall
NIP	Network Information Provision
OIM	Overlay Information Management
OMS	Overlay Management Server
ONIM	Overlay Network Information Management
ORC	Overlay Resource Control
ORCP	Overlay Resource Control Protocol
ORIM	Overlay Resource Information Management
P2P	Peer-to-Peer
PLO	Peer List Optimization
PAMS	Peer Activity Management Server
REST	Representational State Transfer
RS	Relay Server
RSM	Resource Status Management
RSRM	Relay Server Resource Management
RUIM	Resource Usage Information Management
TCP	Transmission Control Protocol
TLS	Transport Layer Security
UDP	User Datagram Protocol
URI	Uniform Resource Identifier
XML	Extensible Markup Language
UMS	User Management Server
UNIS	Underlying Network Information Server

5 Conventions

In this Recommendation:

– The keywords "is required to" indicate a requirement that must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

– The keywords "is recommended" indicate a requirement that is recommended, but which is not absolutely required. Thus this requirement need not be present to claim conformance.

– The keywords "can optionally" indicate an optional requirement that is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Overview

The framework of a managed P2P (MP2P) defined in [b-ISO/IEC TR 20002] includes a cache server (CS) and a relay server (RS) for supporting manageability features enhancing service continuity and sustainability of the P2P network.

The performance of a P2P network is affected by the number of peers. If there is no peer in a P2P network, the P2P network is closed and the management server has to remove the information related to the P2P network. Thus, it is important to maintain a certain number of peers to sustain the P2P network. A CS can be used in this case. An OMS can allocate a CS for a certain overlay network, and the CS joins the overlay network as a peer. After downloading the contents, the CS can remain in the overlay network and act as a seed to the overlay network. Even if there is no peer except the CS participating in the overlay network, a new peer joining the overlay network can find the CS and receive fragments from the CS.

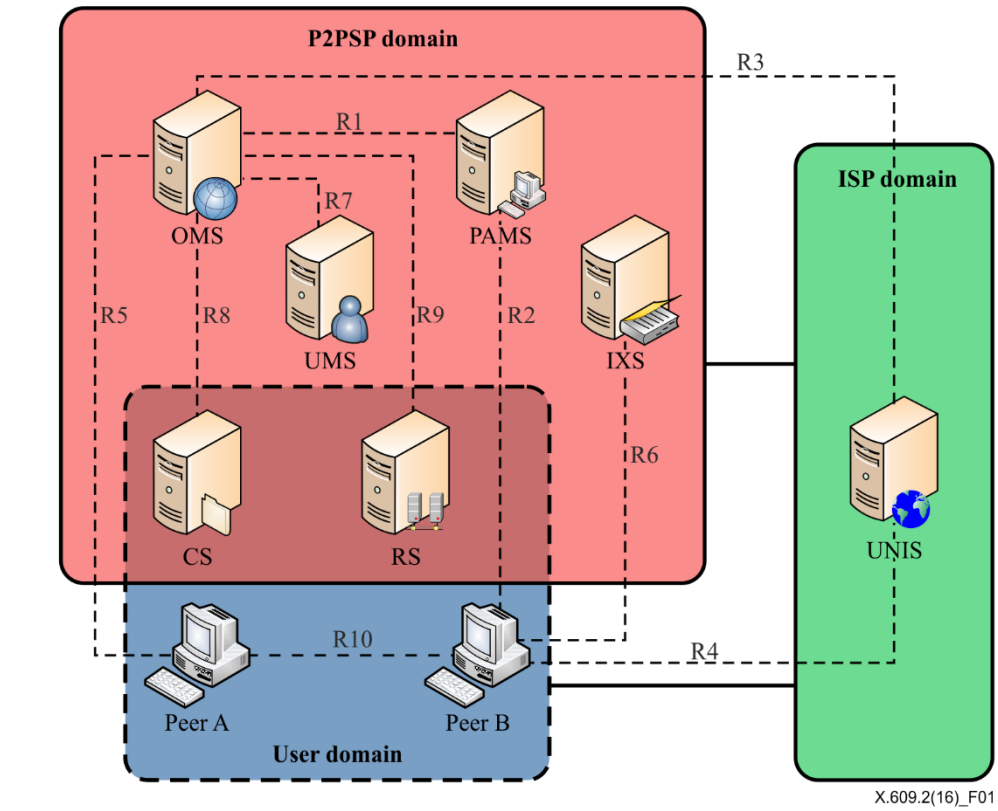
There can be another case in which the peer may not have enough resources to distribute its contents or is unable to participate in a certain P2P network as a leech for retrieving contents. In such a case, a CS can be used as a delegated agent. When a peer possessing insufficient resources wants to distribute its contents, a CS is allocated to the peer and the peer sends the contents to the CS directly. The CS creates an overlay network as a seed on behalf of the peer.

If a peer wants to download specific content, an allocated CS joins the overlay network corresponding to the content on behalf of the peer and downloads it. After complete download, the CS can send the downloaded content to the peer directly. The CS should be allocated to act as a delegated agent.

A peer may reside behind a NAT/FW. In such a case, other peers may not be able to establish a connection to such a peer. Thus, the peer may not be able to properly join the overlay network. An RS is designed to assist such a peer. By allocating an RS for such a peer, the peer can establish a connection with the RS. The connection can be used to relay traffic from/to the peer behind the NAT/FW. Consequently, a peer behind the NAT/FW is able properly to participate in an overlay network.

In order to utilize the CS/RS, a peer needs to interact with the OMS. The OMS manages the resources of the CS/RS with the protocol defined in this Recommendation. This Recommendation also defines a signalling protocol between a peer and the CS/RS for utilizing the resources allocated by the OMS.

Figure 1 shows reference points among components for MP2P communications. The reference points related to the ORCP are denoted as R5, R8, and R9 in Figure 1.



UMS: user profile management server
OMS: overlay management server
PAMS: peer activity management server
RS: relay server
CS: cache server
IXS: index server
UNIS: underlying network information server

Figure 1 – Framework and interface of an MP2P [ITU-T X.609]

7 Requirements of the ORCP

This clause describes requirements for a CS, RS, OMS and peer regarding the ORCP. In an MP2P network, a service provider can provide resources to be used in the overlay network to provide services such as service enhancement of the overlay network, resource delegation and traffic relay by use of the ORCP. In order to support such capability, the ORCP also needs to support management and allocation of resources. This clause defines requirements for the ORCP; i.e., resource management, service enhancement, resource delegation and traffic relay.

7.1 CS/RS management

The CS/RS is managed by the OMS. This clause specifies requirements for managing resources.

[REQ-RES-01] The ORCP is required to support of registration of the CS/RS to the OMS.

[REQ-RES-02] The OMS is required to issue a unique identifier (ID) for the registered CS/RS.

[REQ-RES-03] The ORCP is required to support updating of CS/RS registration.

[REQ-RES-04] The ORCP is recommended to support deregistration of the registered CS/RS.

NOTE – It is possible for the CS/RS to set the expiration time of the registration.

[REQ-RES-05] The OMS is required to keep track of the list of registered CS/RS.

7.2 Resource allocation

Overlay resources are allocated before use by the OMS and peers. This clause specifies requirements for allocation of overlay resources.

[REQ-ALLOC-01] The OMS is required to reserve the overlay resources prior to being used by the overlay network.

[REQ-ALLOC-02] The ORCP is required to support the reservation of resources of the CS/RS.

[REQ-ALLOC-03] The ORCP is required to support updating of overlay resource reservation.

[REQ-ALLOC-04] The ORCP is recommended to support release of registered overlay resources.

[REQ-ALLOC-05] The peer and OMS are recommended to specify the criteria for the release of registered overlay resources.

NOTE – It is possible to set release criteria based on the following resource allocations:

– for a specified period of time;
– until the distribution rate reaches specified value;
– until a specified number of seeders is active;
– until a specified operation is completed;
– until the OMS specifically requests release of the registered overlay resource.

[REQ-ALLOC-06] The OMS and service provider are recommended to support querying of the allocation status of overlay resources.

[REQ-ALLOC-07] The CS/RS is required to manage the overlay resource of the overlay network.

[REQ-ALLOC-08] The OMS is recommended to provide priority information about the overlay resource on requesting resource allocation. This priority information is used to give a higher priority to virtual peers of the CS than an ordinary peer when a peer relationship is established.

7.3 Service delegation

A CS, being a virtual peer, can allocate resources in order to participate in an overlay network on behalf of a peer that does not have enough resources. This feature is called service delegation. For this, the ORCP needs to provide functions to support service delegation.

[REQ-DELEGATE-01] The ORCP is required to be used for service delegation.

[REQ-DELEGATE-02] A virtual peer is required to participate in the overlay network on behalf of a peer through service delegation.

7.4 Traffic relay

An RS is used to relay contents to assist the peer behind the NAT/FW to properly participate in the P2P-based service. The RS maintains the connection with a peer behind an NAT/FW to assist the peer in establishing connection with the peer outside network [ITU-T X.609].

[REQ-RELAY-01] An RS is required to provide traffic relay on behalf of a peer behind an NAT/FW.

[REQ-RELAY-02] The ORCP is required to deliver mapping information allocated by an RS to support traffic relay.

7.5 Transport

These requirements pertain to the transport protocol used in delivery of ORCP messages.

[REQ-TRANS-01] An ORCP message is required to be delivered through a reliable transport protocol, such as the transmission control protocol (TCP).

[REQ-TRANS-02] An ORCP message is recommended to be delivered through an unreliable transport protocol, such as the user datagram protocol (UDP), to convey control messages.

[REQ-TRANS-03] An ORCP message is recommended to be delivered through a secured transport protocol, such as transport layer security (TLS).

8 Protocol operation

This clause describes protocol flows of the CS, RS, peer and OMS to describe the operation and use of messages for the ORCP.

8.1 Basic operation

8.1.1 Registration of CS/RS

This clause provides a description of the procedure for registering the CS/RS. The CS/RS needs to provide information on the resources that it is willing to share. Figure 2 shows the flow for resource registration by the CS/RS.

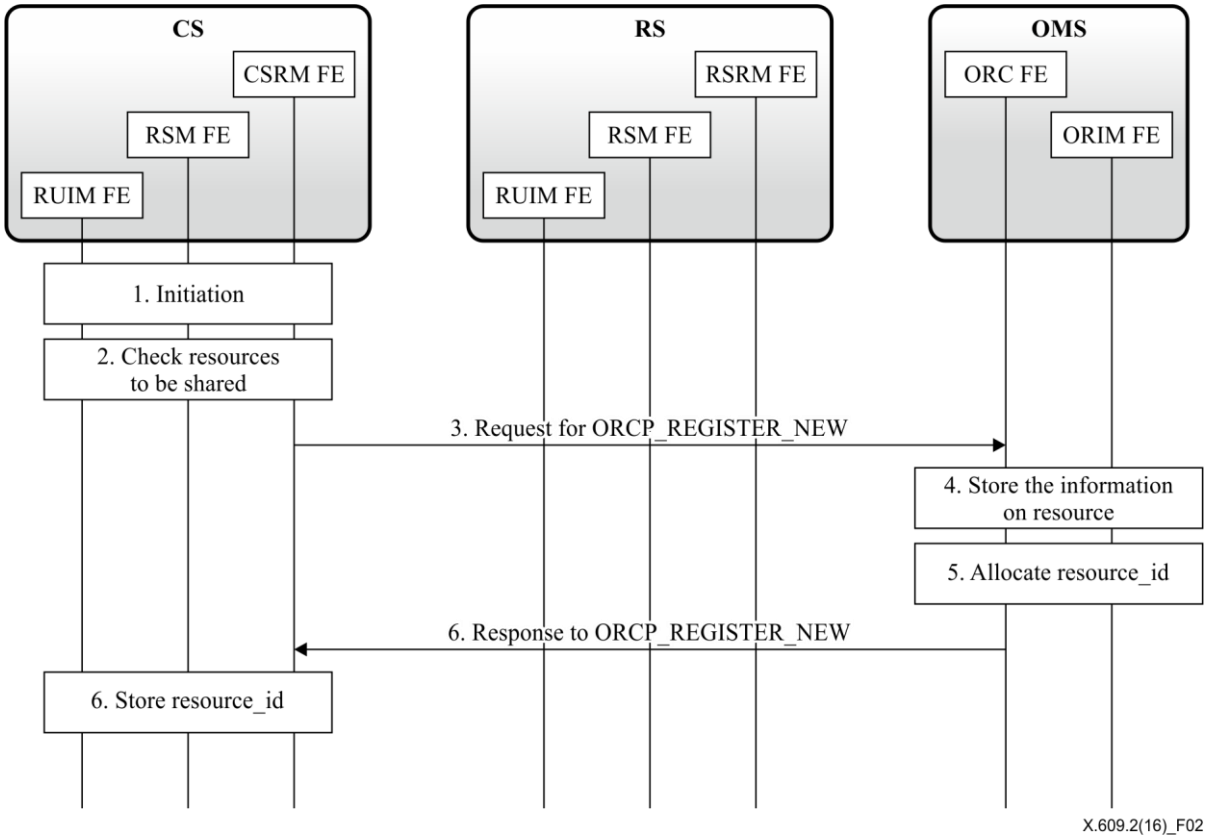


Figure 2 – Flow for registration by CS/RS

As with the initiation, the CS/RS checks the resources to be shared. The CS/RS sends information about the resources to the OMS. The resources can be uplink/downlink bandwidth, number of connection, storage size, etc. The OMS stores the information provided by the CS/RS. The OMS checks the validity of the CS/RS during this procedure. In this procedure, the OMS can classify the type of CS for providing prioritized communications among CSs based on its history of activity, quality of resources. For example, if the CS resides in a service provider domain that can provide overlay resources with stability and a certain level of quality like network bandwidth, it has a higher priority than a CS in the user domain. The OMS also allocates a resource ID for the CS/RS on successful registration. On failure, the OMS sends a reason for failure.

NOTE 1 – The RS follows the same registration procedures as those for the CS/RS. The RS uses the relay server resource management (RSRM) functional entity (FE) instead of the cache server resource management (CSRM) FE.

NOTE 2 – The resource ID must be unique in the MP2P overlay network. The allocation method of the resource ID is equivalent to that of the peer ID, which is not specified in this Recommendation.

8.1.2 Registration updates of CS/RS

The CS/RS can change the resource capacity at any time, if needed. Figure 3 shows the flow for resource updates to be shared by the CS/RS.

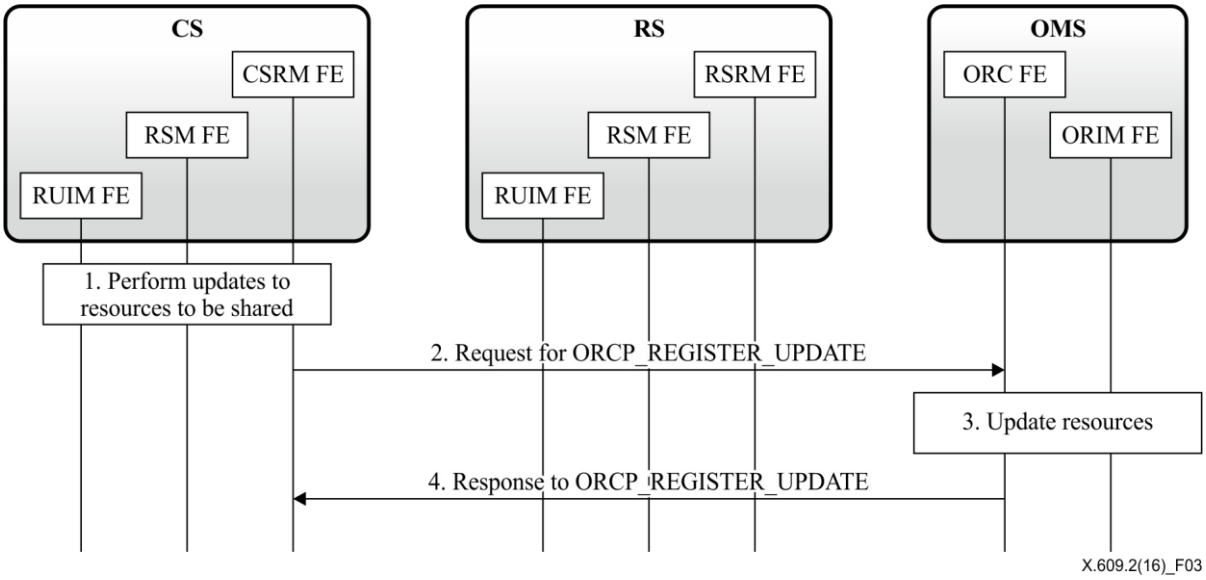


Figure 3 – Flow for updates to the CS/RS

After resource information updates, the CS/RS sends the updated information to the OMS. Since the OMS stores resource information, it makes updates to the changed information provided by the CS/RS. The OMS responds with the update results, which can be a success or failure. On failure, it will send a reason for failure.

NOTE – The RS follows the same procedures to update as those for the CS/RS. The RS uses the RSRM FE instead of the CSRM FE.

8.1.3 Reservation and allocation of overlay resources

This clause provides a description of the usages of overlay resources, and procedures for reserving and allocating overlay resources for those usages.

8.1.3.1 Usages of overlay resources

Overlay resources can be allocated on request from a peer or by the OMS when the OMS decides that the MP2P service needs the use of overlay resources. The following cases describe when the overlay resources are allocated and used.

- *Case 1: Distribution of contents in an overlay network is slow and ineffective.*

One or more CS can participate in an overlay network in order to increase the distribution rate. Normally, a newly created overlay network tends to show a low contents distribution rate. In this case, an OMS or peer can use one or more CS until the distribution rate reaches a predefined value, which is set by the service provider. The CS can retrieve contents from a provider and distribute them in order to increase the distribution rate.

The allocation duration of overlay resources and usage can be varied in various situations. It is possible to set conditions for the release of the allocated overlay resources. The OMS/peer needing overlay resources sets a release condition during CS/RS reservation. The CS release conditions are as follows.

– CS participates for requested period;

– CS participates until the content distribution rate reaches a specified value;

– CS participates until the number of seeds (i.e., peers having entire contents) has reached a specified value;

– If there is no release condition, CS participates until the OMS releases the overlay resources.

• *Case 2: A peer needs to download particular contents, but it is not able to participate in the overlay network.*

A CS can participate in the overlay network on behalf of the requesting peer to retrieve contents. After the CS has retrieved the entire contents, it leaves the overlay network and informs the peer of the completion of the content download. The CS informs the peer through an out-of-band mechanism, such as e-mail or messages. The peer can then fetch the contents from the CS directly. Since the CS has a limited amount of storage, the CS maintains the retrieved data for a specified period.

• *Case 3: A peer needs to distribute contents, but it is not able to participate in the overlay network.*

A CS can participate in the overlay network on behalf of the requesting peer to distribute contents. A Peer can directly send the contents to the CS to be distributed over an overlay network. Regarding the CS release condition, the CS participates for a requested period or until a specified amount of traffic has been delivered. If there is no release condition, the CS participates until the OMS releases the overlay resource.

• *Case 4: A peer is placed behind an NAT/FW, and it cannot retrieve contents from other peers.*

A RS is involved in this case. The RS can retrieve contents from other peers and directly relay the received contents to a requesting peer. Regarding the RS release condition, the RS participates for a requested period or until a specified amount of traffic has been delivered. If there is no release condition, the CS participates until the OMS releases the overlay resource.

Whatever the case, if the peer or OMS still needs overlay resources after the release, it can request further resources through the CS/RS reservation procedure.

8.1.3.2 Reservation of overlay resources in a CS

A peer or the OMS can reserve and use the resources of a CS. The procedure for CS reservation is shown in Figure 4.

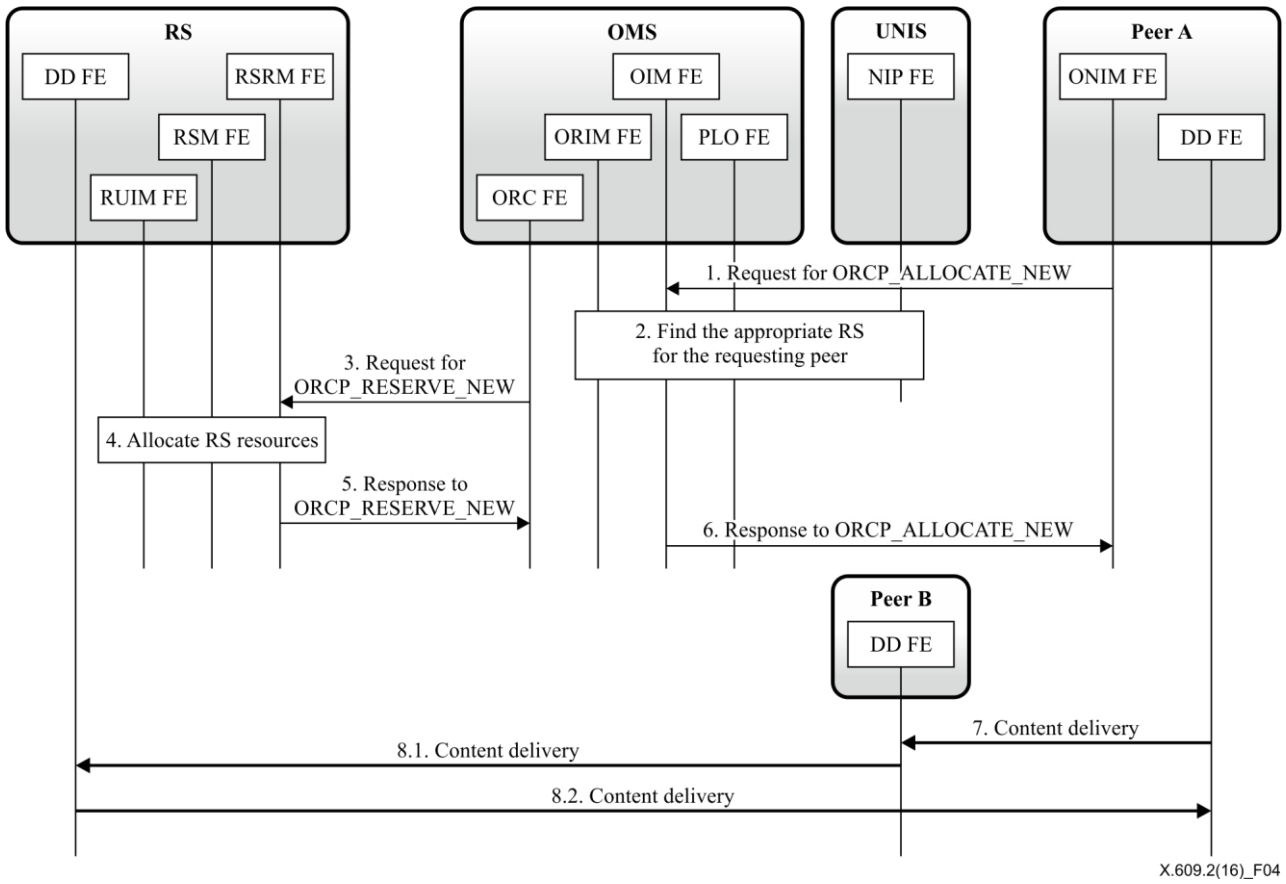


Figure 4 – Flow for CS reservation

If the peer needs overlay resource support, it requests the OMS to provide the resources needed as in step 1. If the OMS needs support from a CS and is reserving resources directly, step 1 and step 7 of Figure 4 should be omitted.

In allocating a CS, the OMS finds the most appropriate CS that is advantageous to the P2P service. For case 1 in clause 8.1.3.1, the OMS needs to find a CS that is relatively distant from seeds. For case 2 and case 3, the OMS selects a CS that is relatively closer to the requesting peer. In order to find a CS from the network distance perspective, the OMS obtains assistance from an underlying network information server (UNIS) in requesting a network score between the allocating peer and the list of CS as in step 2. The OMS also needs to check the allocation status of available CSs to find the CS that is relatively idle in order to fully support the requested service.

The OMS requests reservation of resources from a selected CS. On requesting overlay resources from a CS, the OMS embeds priority information that can be used to identify the type and priority of peer. This information differs according to its priority level. The CS performs a P2P peer join procedure and responds to the OMS with the allocation status. After successful CS reservation, the CS is used in the overlay network.

For case 1 in clause 8.1.3.1, the CS acts as an ordinary peer, sending/receiving contents from peer A and peer B as in step 8.1 and step 8.2. For case 2 in clause 8.1.3.1, a peer sends/receives contents from other peers as in step 8.2. After completion of download, the CS delivers contents to peer A as in step 8.1. For case 3 in clause 8.1.3.1, the CS receives contents from peer A as in step 8.1 and delivers contents to other peers as in step 8.2.

8.1.3.3 Reservation of overlay resource in an RS

A peer can reserve and use the resources of an RS. The procedure for RS reservation is shown in Figure 5.

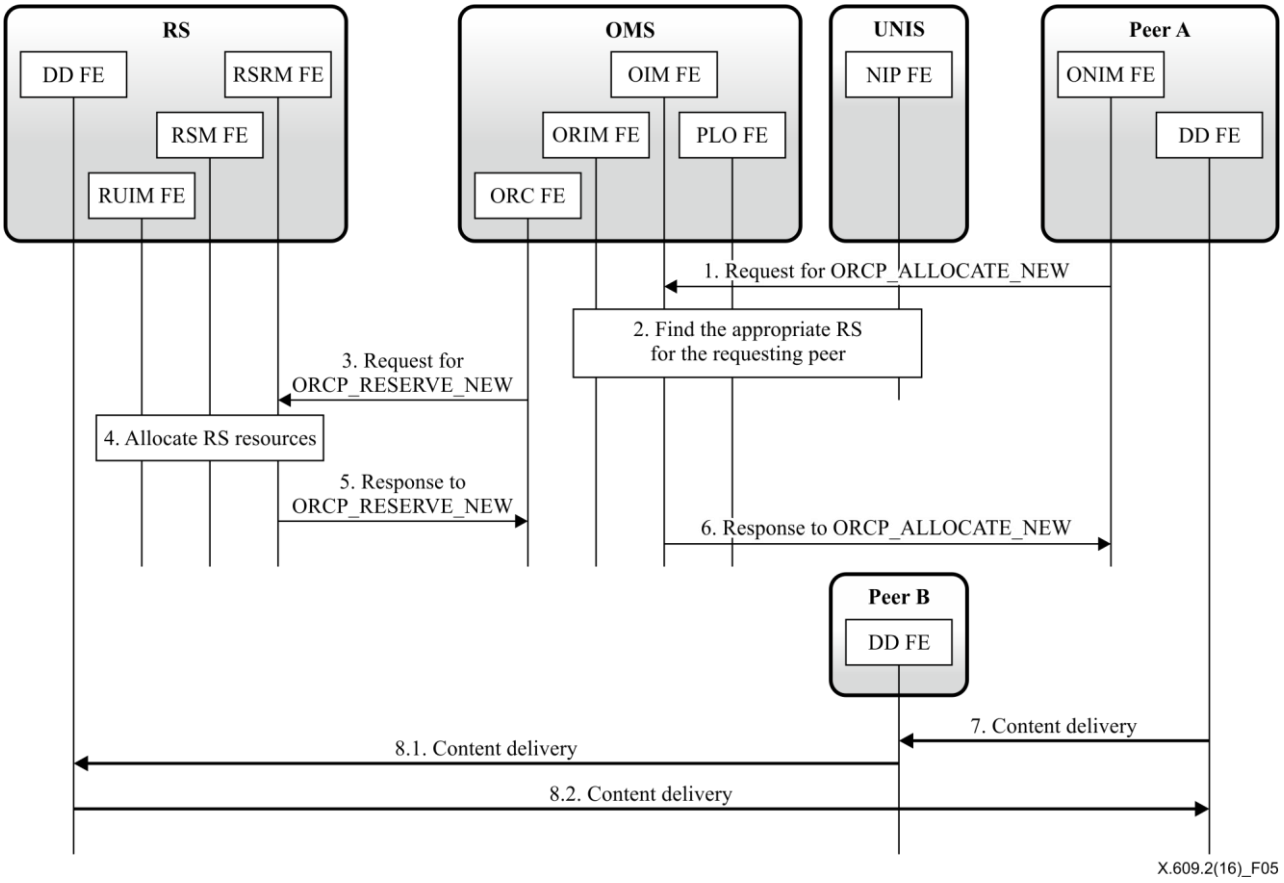


Figure 5 – Flow for RS reservation

A peer placed behind an NAT/FW as in case 4 of clause 8.1.3.1 needs support from an RS. A peer request for reservation of an RS to an OMS is as in step 1.

In allocating an RS, an OMS finds the most appropriate RS that can support the peer behind an NAT/FW. It would be appropriate to select an RS that is closer to the requesting peer from the network distance perspective. This information can be acquired from a UNIS requesting a network score between the requesting peer and the list of RSs as in step 2. The OMS also needs to check the allocation status to find an RS that is relatively idle in order to fully support the requested service.

The OMS requests reservation of resources from the selected RS. After successful RS reservation, the RS is used in the overlay network. The contents that are sent from peer A are delivered directly to peer B as in step 7. However, contents from peer B are delivered to the RS, as in step 8.1, and are then forwarded to peer A as in step 8.2.

8.1.4 Updates to allocation/reservation of overlay resources

The OMS or peer may want to update the allocated overlay resources. The procedure for updating allocated resources is shown in Figure 6.

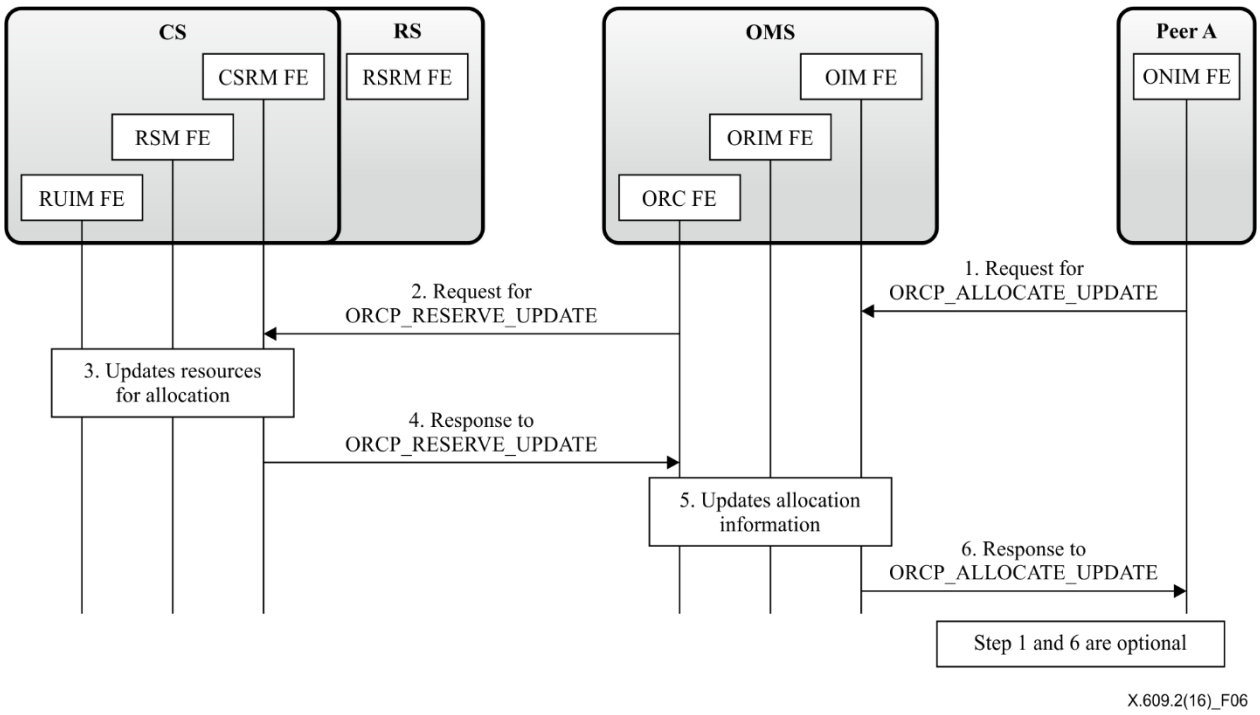


Figure 6 – Flow for updates to overlay resources

A peer needing allocated resource updates can make changes to the reservation using the resource ID and the virtual peer ID/relay instance ID as shown in step 1. If the OMS finds the need to update the allocated resources of a CS/RS, step 1 and step 6 are omitted. The OMS requests the CS/RS for reservation updates to the overlay resource used in a particular overlay network. The CS/RS checks to see if the update can be accepted, if it is possible it updates the overlay resource as in step 3. The CS/RS responds to the update as in step 4. The OMS updates the CS/RS allocation-related information and responds to a peer as in step 6.

8.1.5 Release of allocated overlay resources

An OMS or peer may no longer need the support from a CS/RS. In this case, the OMS needs to release the allocated resource. The procedure for release of allocated overlay resource is shown in Figure 7.

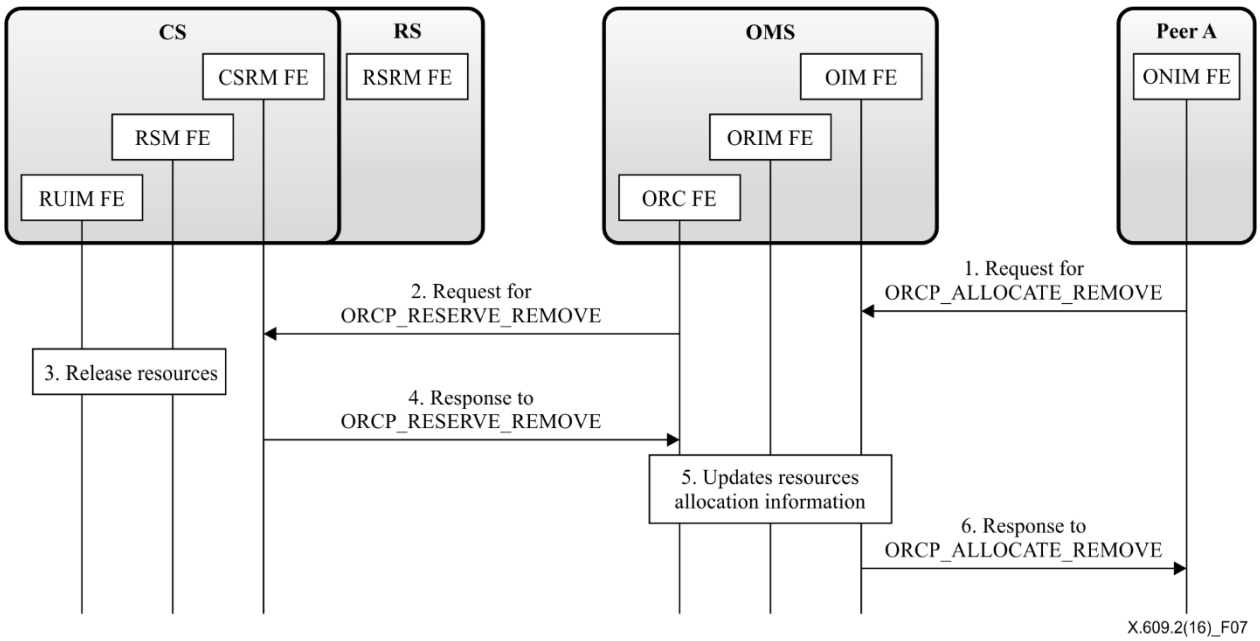


Figure 7 – Flow for release of overlay resources

A peer no longer needing the resources of an CS/RS can explicitly return the particular resource through using the resource ID and virtual peer ID/relay instance ID as shown in step 1. If the OMS decides to release the resources of an CS/RS, step 1 and step 6 are omitted. The OMS requests a CS/RS to release the resources used in the overlay network. The CS/RS removes the allocated information and responds to the OMS concerning the release result as in step 4. The OMS updates the CS/RS allocation-related information.

8.1.6 Probing allocation status of overlay resources

This clause provides a description of the protocol operation of probing the status of overlay resources of an CS/RS. The OMS or MP2P service administrator may need to know the resource allocation status of the CS/RS. It is possible to probe resource allocation status for a single peer and for all peers.

8.1.6.1 Probing resource allocation status for single peer

Figure 8 shows the flow for a peer probing its resource allocation status. The peer sends a get resource message to the OMS. The OMS sends a status resource message with the overlay resource ID. The CS/RS sends a response of status OK or error with the appropriate reason. The OMS forwards the response to the requesting peer.

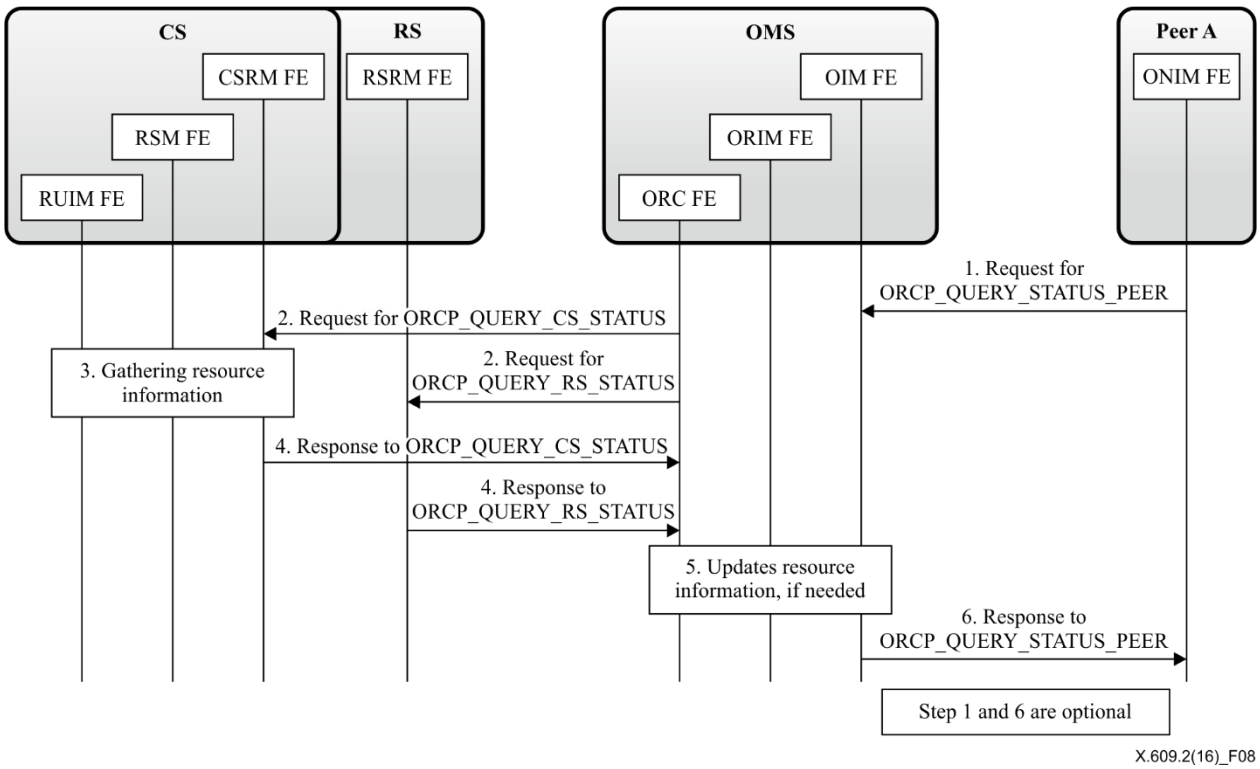


Figure 8 – Flow for peer probing resource allocation status

The OMS or MP2P service administrator can probe for the resource allocation status on a single peer to the CS/RS. In this case, only steps 2 to 4 will be used.

8.1.6.2 Probing full resource allocation status

Figure 9 shows the flow for probing full resource allocation status. Although the flow shows only OMS probing full resource allocation status, it is possible for the MP2P service administrator to probe for full resource allocation status using the same status resource message and status response message.

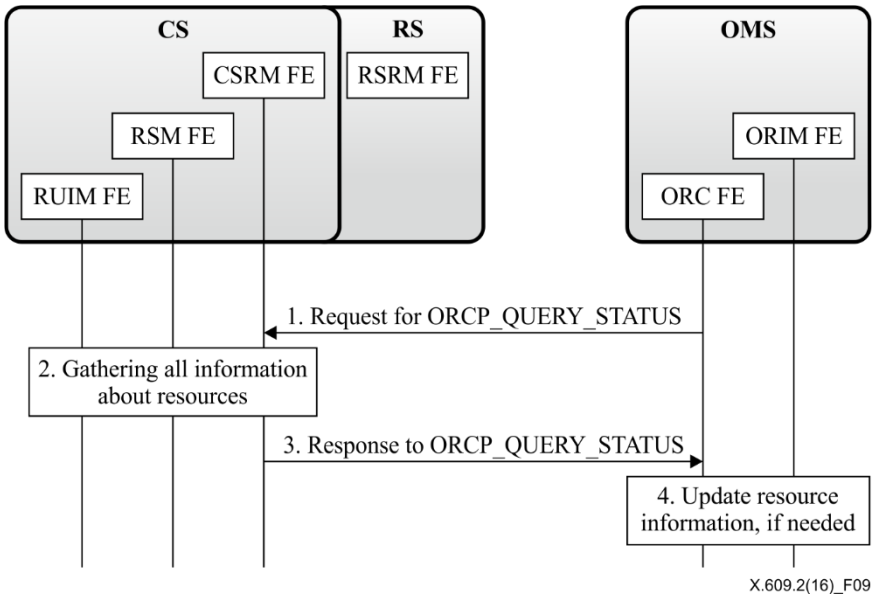


Figure 9 – Flow for probing full resource allocation status

8.1.7 Recovery from failure of overlay resource

This clause describes the protocol operation for recovery of a resource failure.

Figure 10 shows the flow for a failure recovery process during resource error. Peer A sends/receives contents to/from a CS/RS as in step 1. Suddenly, the CS/RS fails as in step 2, then peer A is unable to communicate with the CS/RS and peer A can detect the failure of CS/RS as in steps 3–4. The peer asks the OMS to check the CS/RS and remove the CS/RS information from its memory as in steps 5-7. The OMS checks the status of the CS/RS as in step 5. If there is no response from the CS/RS, the OMS removes the CS/RS information. If the service continuously needs support from the CS/RS, the OMS and peer perform a resource reservation process with another CS/RS as in step 8.

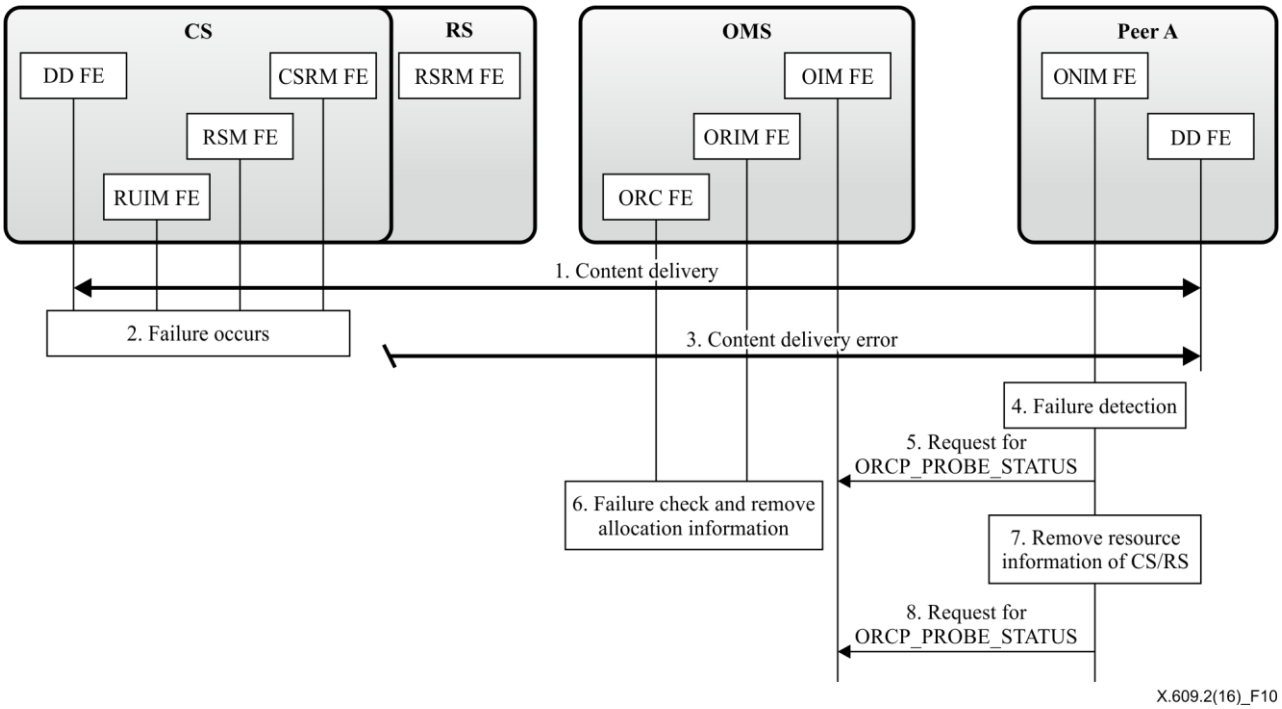


Figure 10 – Flow for failure recovery on CS/RS error

8.1.8 Periodic refresh of registration and allocation

Since the registration can be expired based on expires of registration and allocation, it needs to be refreshed before timeout fires.

8.1.8.1 Refresh of CS/RS registration

A CS/RS can periodically report its operational status through the procedure shown in Figure 11.

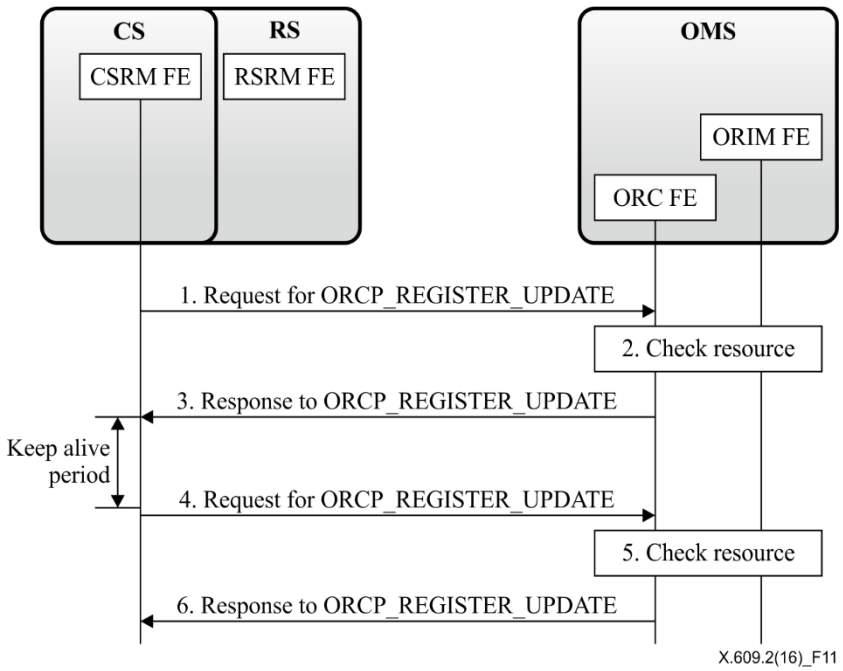


Figure 11 – Flow for refreshing CS/RS registration

The CS/RS can use the same message as the CS/RS registration updates in clause 8.1.2. The reason for using the same message is that it is possible to maintain consistency between the CS/RS and OMS regarding resource information for sharing. The CS/RS uses a timer for the keep alive procedure. After timeout, the CS/RS sends a registration update message to the OMS. The OMS checks the status of resources and responds with OK or error.

8.1.8.2 Refresh of resource allocation

A peer can periodically report its resource allocation status to the OMS using the procedure shown in Figure 12. This report is needed to maintain overlay resource allocation consistency between the peer and the OMS. If the OMS discovers inconsistency of overlay resource allocation, it responds with an error and the resource should be released.

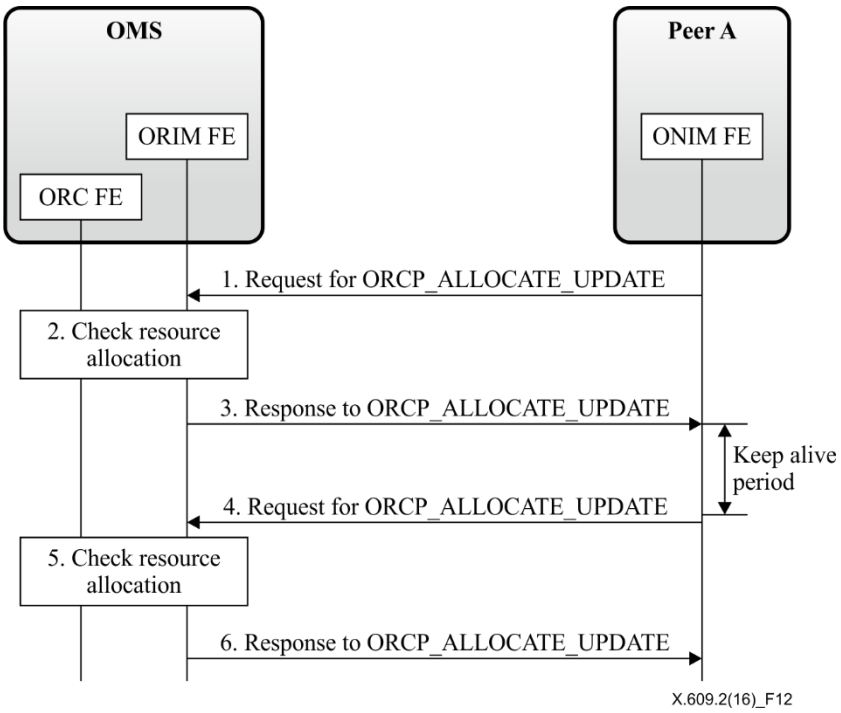


Figure 12 – Flow for refreshing resource allocation

A peer can use the same message as the request updates in clause 8.1.4. The reason for using the same message is that it is possible to maintain consistency between the peer and the OMS regarding overlay resource information. The peer uses a timer for this procedure. After timeout, the peer sends a request update message to the OMS. The OMS checks the status of overlay resource allocation and responds with OK or error.

8.1.9 Deregistration of CS/RS

A CS/RS needs to release the allocated overlay resources before its deregistration. The flow for deregistration of a CS/RS is shown in Figure 13.

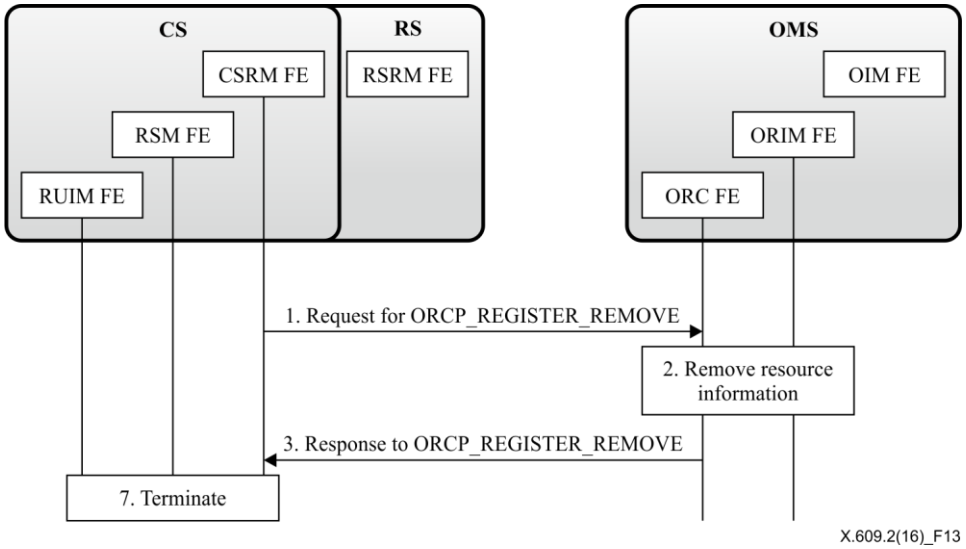


Figure 13 – Flow for deregistration of CS/RS

The CS/RS sends a message to the OMS to notify of its deregistration as in step 1. The OMS removes any information related to deregistering the CS/RS and responds to the request.

The CS/RS can be currently in use by any peer. However, the peer can detect any CS/RS problem using the procedures in clauses 8.1.7 and 8.1.8. Upon detection of the absence of CS/RS from use, the peer releases the overlay resource and performs the overlay resource reservation procedure in clause 8.1.3.

8.2 Extended operation

This clause describes extended operations for the ORCP.

8.2.1 Reporting overlay resource utilization status

When the OMS decides on the allocation and retrieval of the overlay resource of a CS/RS for a specific overlay network, it needs to know the resource utilization status of the CS/RS. Figure 14 shows flows for finding their status by receiving reports from the CS/RS.

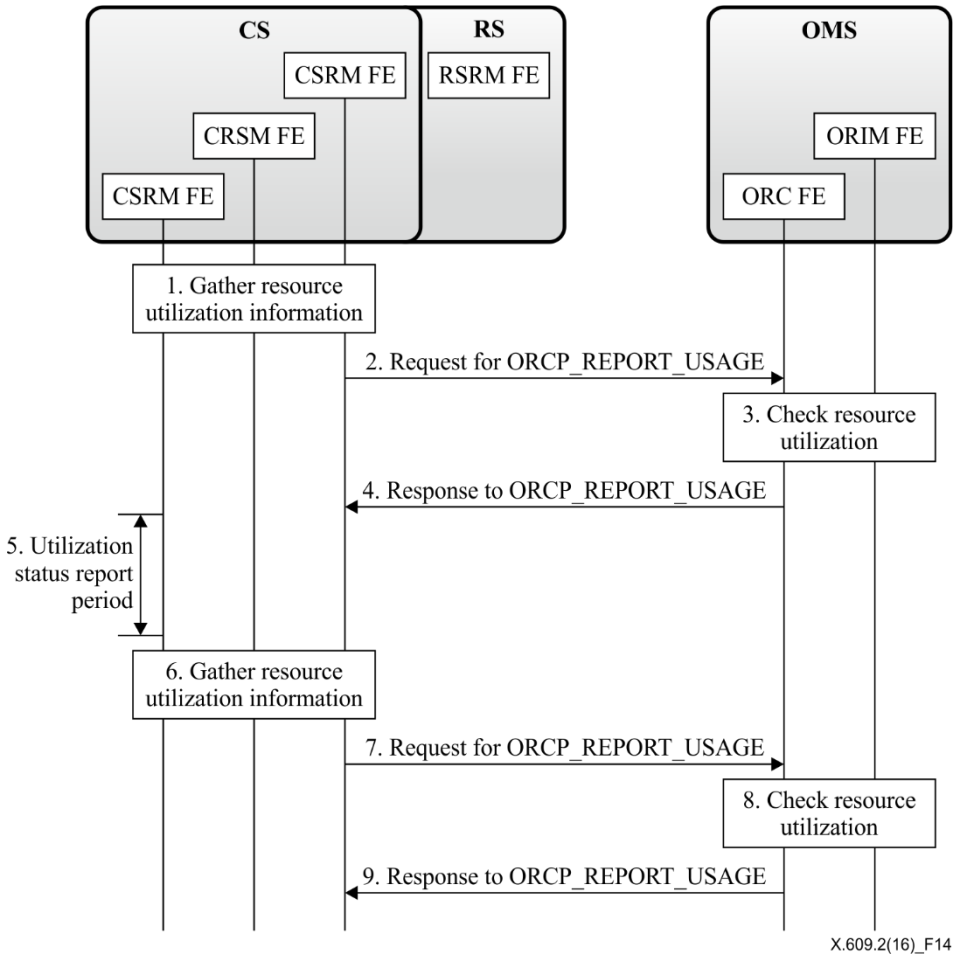


Figure 14 – Flow for CS/RS resource utilization report

The CS/RS gathers its overlay resource utilization status (step1), and sends it to the OMS using an ORCP_USAGE_REPORT message as shown in step 2 and 4. In step 3, the OMS decides on allocating or releasing overlay resource by analysing the status information gathered from the CS/RS. It is also possible to make use of other information by interacting with a peer activity management server (PAMS). When it decides to allocate a new virtual peer, the OMS can consider several factors, such as network distance from the source peer, network distance from peers in need, on choosing an appropriate CS/RS. These procedures are repeated periodically as shown in steps 5–9.

8.2.2 Reporting peer list in distant location for live streaming services

In order to realize the contents distribution structure for live streaming, the OMS needs to make a decision about allocating CS(s) in appropriate location(s) for peers to retrieve contents from a close CS from the network perspective. The CS and OMS can share information about the peers served by virtual peers running on the CS. The OMS can provide the CS with information about the peers distant from the CS. The CS can periodically provide a list of peers from distant locations that it has serviced. This information can be used by the OMS in allocating the appropriate CS to be used in the overlay network for live streaming.

The flow for providing a list of peers in distant locations is shown in Figure 15. The CS can periodically (refer to step 9) report these lists to the OMS. After every reporting period timeout, the CS sends the list of peers in distant locations that it has serviced as shown in step 1 and step 10. The CS also requests the new list of peers from the OMS. The OMS checks if there are changes in the peers in the overlay network. The OMS interfaces with the UNIS the get the ordered peer list with regards to the network distance from the CS. In Figure 15, peer B and peer C are calculated to be distant from CS as shown in step 3. The OMS responds to the CS with peer B and peer C as in step 4. The CS stores this information. As peers interface with the CS, the CS checks if the peer that it had serviced is part of the received peer list. In Figure 15, the CS interacts with peer B, which is a one of the peers in distant locations, and adds it to the peer list that will be notified to the OMS in step 10.

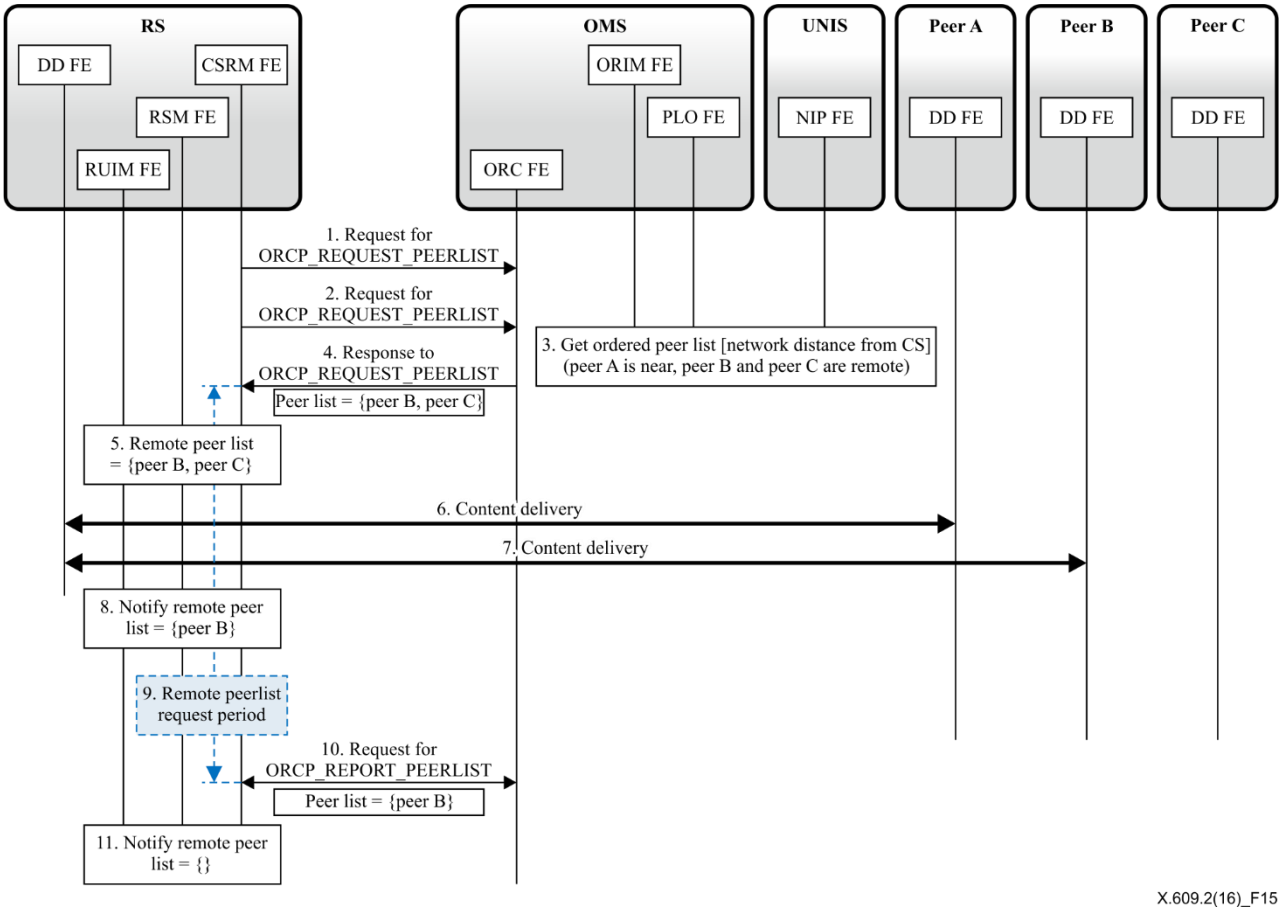


Figure 15 – Flow for reporting a peer list in distant locations

Figure 16 shows the flow for the OMS to select a new CS to be added to the overlay network by using the information from the peer list in the report from the CS. In Figure 16, CS1 informs the OMS that peer B and peer C are the peers from distant locations that it has serviced. The OMS interacts with the UNIS to find an adequate CS that is appropriate in servicing both peer B and peer C as in step 2. The OMS selects CS2 and reserves the CS2 to be used in the overlay network.

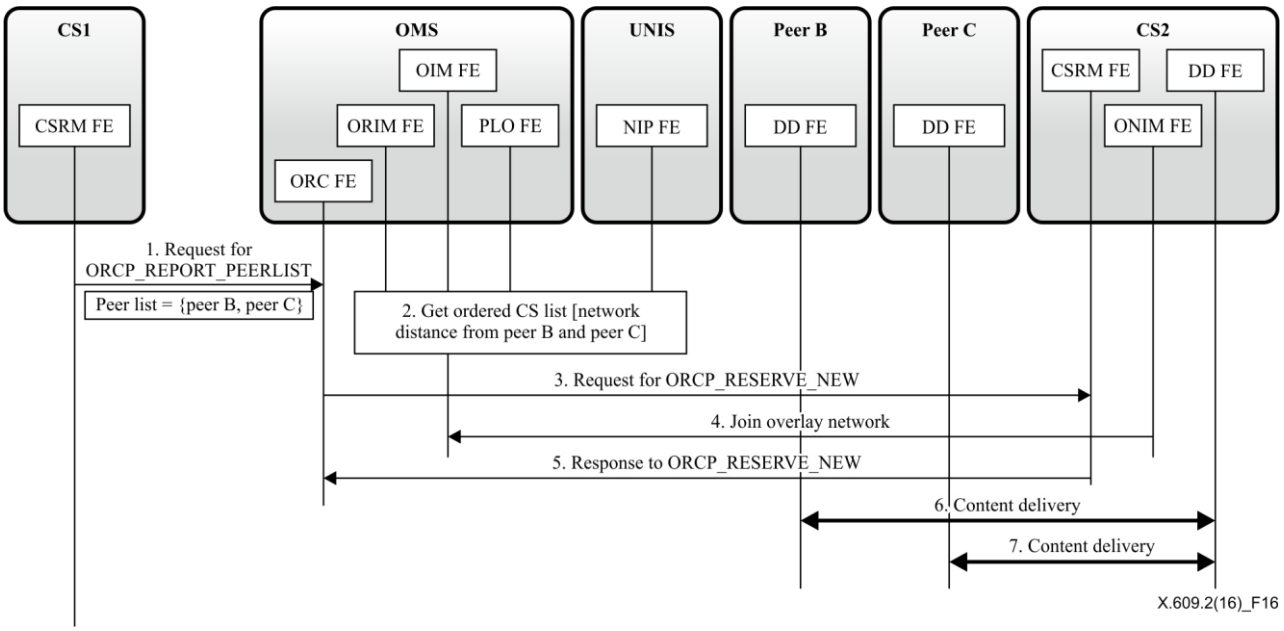


Figure 16 – Flow for selecting a new CS to be added to an overlay network

8.2.3 Prioritization on the overlay resource of CS

In order to enhance the performance of an overlay network that has a massive number of concurrent peers, multiple virtual peers are initiated and put into an overlay network. These virtual peers behave like any ordinary peers in the overlay network, and need to get contents prior to ordinary peers to enhance the distribution performance of the overlay network. This clause describes extended operations to provide prioritization for virtual peers of the CS as shown in Figure 17.

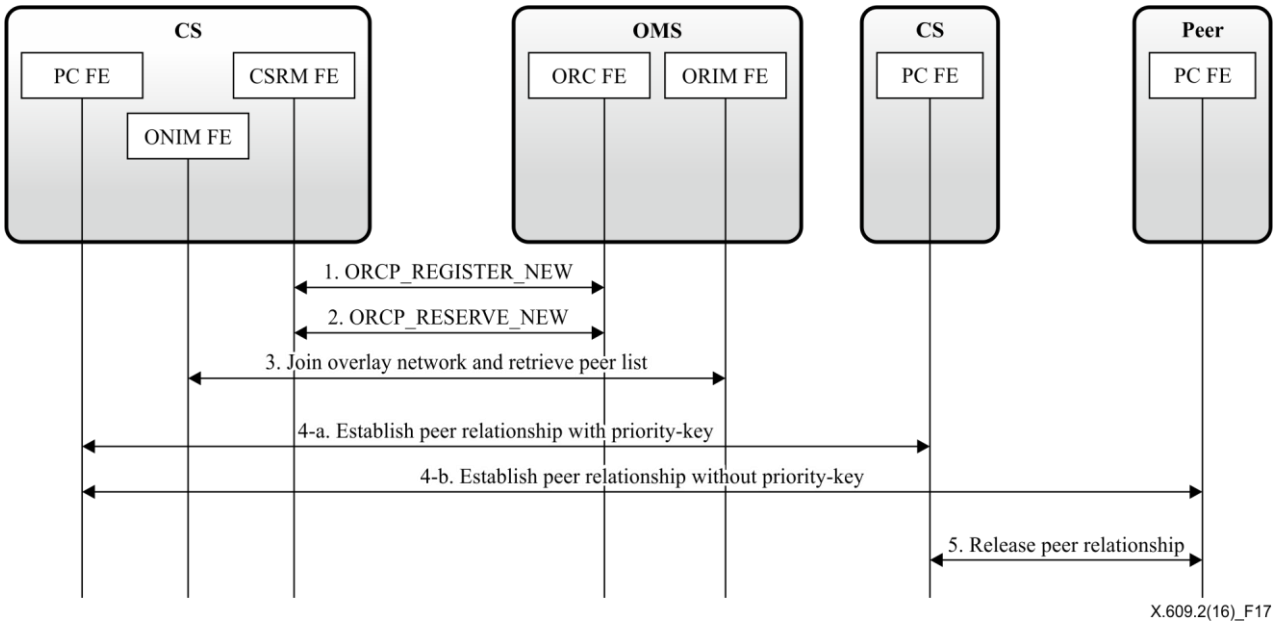


Figure 17 – Flow for prioritization of virtual peers of a CS

When an CS registers on the OMS, the OMS assigns a resource ID that is used to identify and access CS information as described in clause 8.1.1 (step 1). In this step, the OMS internally sets the priority level of the CS based on its activity history or predefined policy of the OMS. For example, if the CS is provided by a trustable service provider, this would have more priority than a CS from a voluntary user.

On resource reservation procedures (step 2), the OMS requests the CS to initiate a virtual peer instance with a *priority-key* that is used to identify its priority level. On successful creation of virtual peers, the CS responds to the OMS with messages defined in clause 9.1.10.

When a virtual peer requests the OMS to give the peer list of a particular overlay network, the OMS sends the peer list including the overlay resources for the virtual peer based on its priority level (step 3). The peer list includes information about the virtual peer of the CS that pushes contents received from the source or other CS, and the virtual peers of the CS have the latest fragment in the case of multimedia streaming services. Since the OMS can figure out the level of the requesting peer, it gives additional information, such as type of peer, the length of the *priority_key*, and the peer's network information. When the OMS sends the peer list to an ordinary peer, it does not include the priority_key, since it should not be exposed to prevent load concentration.

In peer communication procedures, a virtual peer establishes a peer relationship with other virtual peers of the CS with its priority_key (step 4-a). When it comes to try to establish a peer relationship with an ordinary peer(s) that does not have priority information, it does not include its priority_key in the request message. If a corresponding peer has no available resources, it releases the relationship with the ordinary peer (step 5).

9 Messages and parameters

This clause describes the format of ORCP messages. For extensibility, ORCP adopts representational state transfer (REST) architecture, a style of software architecture for distributed systems. The most common encoding formats used in REST are JavaScript object notation (JSON) and extensible markup language (XML). This Recommendation uses the text type JSON encoding.

It is possible to extend the elements or attributes to the resource element type to customize existing features and support new properties and capabilities for different operating environments. Extending the protocol implies adding new features without changing the protocol itself. The extension must not alter the existing protocol and must support backward capability.

9.1 Resource element type

This clause provides the format of resource element types used in this Recommendation. The grammar used in representing objects defined in this Recommendation is as follows:

– "STRING", "BOOLEAN", and "NUMBER" are types are used to indicate string, boolean, and number, respectively;

– An array of collective values are enclosed in brackets "[ ]" with values separated by a comma ",";

– Any selective options are separated by a vertical bar " | ".

9.1.1 Resource capacity element

The resource capacity element identifies the amount of resource that the CS/RS is willing to share. The generic definition of the resource capacity element is as follows.

```
Object {
  NUMBER        max_storage_size;
  NUMBER        max_uplink_bandwidth;
  NUMBER        max_downlink_bandwidth;
  NUMBER        max_num_connection;
  NUMBER        max_num_overlay_network;
} resource_capacity;
```

The description of the attributes is as follows:

– max_storage_size indicates the maximum size of the storage for sharing – this attribute is used by the CS;

– max_uplink_bandwidth indicates the maximum uplink bandwidth for sharing;

– max_downlink_bandwidth indicates the maximum downlink bandwidth for sharing;

– max_num_connection indicates the maximum number of connections possible for sharing;

– max_num_overlay_network indicates the maximum number of overlay networks that can be joined by the CS/RS.

9.1.2 Reservation requirement element

The reservation requirement element identifies the amount of resource that is reserved for use by the overlay network. The generic definition of the reservation requirement element is as follows.

```
Object {
  NUMBER        storage_size;
  NUMBER        uplink_bandwidth;
  NUMBER        downlink_bandwidth;
  NUMBER        num_connection;
} reservation_requirement;
```

The description of the attributes is as follows:

– storage_size indicates the size of the storage reserved – this attribute pertains to the CS;

– uplink_bandwidth indicates the uplink bandwidth reserved;

– downlink_bandwidth indicates the downlink bandwidth reserved;

– num_connection indicates the number of connection reserved.

9.1.3 Leave condition element

The leave condition element identifies the condition where the CS/RS withdraws overlay resources and leaves the overlay network. The generic definition of the leave condition element is as follows.

```
Object {
  NUMBER        timeout;
  NUMBER        max_traffic;
  NUMBER        num_seeder;
  BOOLEAN       service_completion;
} leave_condition;
```

The description of the attributes is as follows:

– timeout indicates the timeout time of resource usage – the resource is returned after the expiration of the values in attribute timeout;

– max_traffic indicates the network traffic volume processed by the CS/RS – the resource is returned after the CS/RS has processed the specified traffic volume;

– num_seeder indicates the number of seeder – the resource is returned after the number of seeders has reached specified value in attribute num_seeder (Note, overlay network tends to be stable when there are sufficient number of seeds);

– service_completion indicates the return of resource after the requested task is completed.

9.1.4 Reservation status element

The reservation status element identifies the status of the resources reserved by the CS/RS. The generic definition of the reservation status element is as follows.

```
Object {
  NUMBER        storage_size;
  NUMBER        upload_traffic;
  NUMBER        download_traffic;
  NUMBER        uplink_bandwidth;
  NUMBER        downlink_bandwidth;
  NUMBER        num_connection;
} reservation_status;
```

The description of the attributes is as follows:

– storage_size indicates the size of the storage reserved – this attribute pertains to the CS;
– upload_traffic indicates the upload network traffic volume processed;
– download_traffic indicates the download network traffic volume processed;
– uplink_bandwidth indicates the uplink bandwidth reserved;
– downlink_bandwidth indicates the uplink bandwidth reserved;
– num_connection indicates the number of the connection reserved.

9.1.5 Authentication element

The authentication element identifies the type of authentication used by the overlay network. The generic definition of the authentication element is as follows.

```
Object {
  STRING        closed = "YES"|"NO"|"KEY";
  STRING        key;
} authentication;
```

The description of the attributes is as follows:

– closed indicates whether the overlay network is closed, open or accessible with a key;
– key indicates the key string used to join the overlay network – it is valid only if the attribute closed is set to the value "KEY".

9.1.6 Network address element

The network interface element identifies the network address and port number. The generic definition of the network interface element is as follows.

```
Object {
  STRING        address;
  NUMBER        port;
} network_address;
```

The description of the attributes is as follows:

– address indicates the network address (i.e., IPv4, IPv6, etc.);
– port indicates the network port number.

9.1.7 Resource registration element

The resource registration element provides information about CS/RS resources. The generic definition of the resource registration element is as follows.

```
Object {
  STRING              type = "CS"|"RS";
  STRING              cs_url;
  network_address     address;
  NUMBER              expires;
  resource_ capacity  resource_capa;
} resource_registration;
```

The description of the attributes is as follows:

– type indicates the type of node registering the resource – its value shall be set to either "CS" or "RS";

– cs_url indicates the URL of CS registering the resource – it is valid only if the attribute type is set to the value "CS";

– address indicates the network address of CS/RS registering the resource – it is the object of the network_address (refer to clause 9.1.6) element;

– expires indicates the expiration time in minutes of the resource for registration – after the expiration time, the resources of the CS/RS are no longer valid;

– resource_capa indicates the resource capacity shared by the CS/RS registering the resource – it is the object of the resource_capacity (refer to clause 9.1.1) element.

9.1.8 Resource registration response element

The resource registration response element provides information about the resource during resource registration. The generic definition of the resource registration response element is as follows.

```
Object {
  STRING    resource_id;
  NUMBER    expires;
  NUMBER    period_keepalive;
  NUMBER    period_utilization_status;
  NUMBER    period_peerlist;
} registration_response;
```

The description of the attributes is as follows:

– resource_id indicates the identifier for resource of CS/RS;

– expires indicates the expiration time in minutes of the registration – the value is set to less than or equal to the value set in the attribute expires in the registration element;

– period_keepalive indicates the recommended report cycle in second for the ORCP_REGISTER_UPDATE request message.

– period_utilization_status indicates the recommended report cycle in second for the ORCP_REPORT_USAGE request message;

– period_peerlist indicates the recommended report cycle in second for the ORCP_REQUEST_PEERLIST request message.

9.1.9 Resource registration update element

The resource registration update element provides updated information about the resources shared by the CS/RS. The generic definition of the resource registration update element is as follows.

```
Object {
  STRING              type = "CS"|"RS";
  NUMBER              expires;
  resource_capacity   resource_capa;
} registration_update;
```

The description of the attributes is as follows:

– type indicates the type of node sharing the resource – its value shall be set to either "CS" or "RS";

– expires indicates the expiration time in minutes of the resource – after the expiration time, the resources of the CS/RS are no longer valid;

– resource_capa indicates the resource capacity shared by CS/RS – it is the object of the resource_capacity (refer to clause 9.1.1) element.

9.1.10 Overlay resource reservation element

The overlay resource reservation element indicates information about the reservation required by the requesting entity. The generic definition of the overlay resource reservation element is as follows.

```
Object {
  STRING              index_url;
  STRING              resource_id;
  authentication      auth;
  STRING              requester_peer_id;
  STRING              action_type = "PEER" | "UPLOAD" | "DOWNLOAD" | "RELAY";
  STRING              notification_address;
  reservation_requirement   require;
  leave_condition           leave;
  STRING              priority_key;
} overlay_resource_reservation;
```

The description of the attributes is as follows:

– index_url indicates the URL of the information about the overlay network where the overlay resource will be used;

– resource_id indicates the identifier of the resource – this value can be omitted when this object is used by a peer;

– auth indicates the authentication method used in joining the overlay network – this value can be omitted when reserving a relay instance of the RS – it is the object of the authentication (refer to clause 9.1.5) element;

– requester_peer_id indicates the identifier of the peer requesting the reservation;

– action_type indicates the type of action to be performed by the overlay resource. If the value is set to "PEER", the overlay resource acts as a virtual peer. If the value is set to "UPLOAD", the overlay resource acts as a peer to upload contents on behalf of the requesting peer. If the

value is set to "DOWNLOAD", the overlay resource acts as a peer to download contents on behalf of the requesting peer. If the value is set to "RELAY", the overlay resource acts as a relay instance;

– notification_address indicates the network address of the peer to be used when there is a need to notify the requesting peer of an event – this value can be omitted when the entity using this object is the OMS;

– require indicates the amount of resource needed – it is the object of the reservation_requirement (refer to clause 9.1.2) element:

  • leave indicates the condition to release the reserved overlay resources – it is the object of the leave_condition (refer to clause 9.1.3) element,

  • priority_key includes the particular length of a random string that is assigned to an overlay network, and the length is dependent on its priority – if it has highest priority, it will have the full length of the priority_key.

9.1.11 Overlay resource reservation response element

The overlay resource reservation response element indicates the result of the reservation and information needed in using the overlay resource. The generic definition of the overlay resource reservation response element is as follows.

```
Object {
  STRING          resource_id;
  STRING          virtual_peer_id;
  STRING          relay_instance_id;
  NUMBER          expires;
  network_address address;
  STRING          link_address;
} reservation_response;
```

The description of the attributes is as follows.

– resource_id indicates the identifier of the resource to be used for this reservation – this value can be omitted when this object is used by OMS;

– virtual_peer_id indicates the identifier used by the reserved overlay resource in the CS – this attribute is used when the overlay resource is a virtual peer;

– relay_instance_id indicates the identification used by the reserved overlay resource in the RS – this attribute is used when the overlay resource is a relay instance in the RS – when a peer needs to re-join the overlay network (i.e., in case of restart), a new relay instance can be allocated with the original relay instance being timeout;

– expires indicates the maximum time that the overlay resource is allocated for this reservation;

– address indicates the network address and port of the reserved overlay resource – it is the object of the network_address (refer to clause 9.1.6) element – this attribute is used when the attribute action_type is set to "RELAY";

– link_address indicates the link address of the virtual peer when uploading/downloading contents – this attribute is used when the attribute action_type is set to "UPLOAD" or "DOWNLOAD".

9.1.12 Overlay resource reservation error response element

The overlay resource reservation error response element indicates error in overlay resource reservation along with the capacity available by the responding entity. The generic definition of the overlay resource reservation error response element is as follows.

```
Object {
  STRING              reason;
  resource_capacity   resource_capa;
} reservation_error;
```

The description of the attributes is as follows:

– reason indicates the reason of the response;

– resource_capa indicates the capacity available by the overlay resource – it is the object of the resource_capacity (refer to clause 9.1.1) element.

9.1.13 Overlay resource reservation update element

The overlay resource reservation update element indicates updated information about the overlay resource required by the requesting entity. The generic definition of the overlay resource reservation update element is as follows.

```
Object {
  STRING                    resource_id;
  STRING                    virtual_peer_id;
  STRING                    relay_instance_id;
  reservation_requirement   require;
  leave_condition           leave;
} reservation_update;
```

The description of the attributes is as follows:

– resource_id indicates the identifier of resource to be used for this reservation – this value can be omitted when this object is used by the OMS;

– virtual_peer_id indicates the peer identification that use the resource in the overlay network – this attribute is for the CS;

– relay_instance_id indicates the identifier of relay instance – this attribute is used for the RS;

– require indicates the required resource to be reserved from the CS/RS – it is the object of the reservation_requirement (refer to clause 9.1.2) element;

– leave indicates the condition when the resource reserving entity returns the reserved overlay resources – it is the object of the leave_condition (refer to clause 9.1.3) element.

9.1.14 Failure reason element

The failure reason element indicates reason for the response especially used in the error case. The generic definition of the failure reason element is as follows.

```
Object {
  STRING    reason;
} failure_reason;
```

The description of the attribute is as follows:

– reason indicates the reason for the response.

9.1.15 CS resource allocation status element

The CS resource allocation status element identifies the amount of resources of the CS that has been allocated. The generic definition of the CS resource allocation status element is as follows.

```
Object {
  STRING              overlay_id;
  STRING              virtual_peer_id;
  STRING              action_type = "PEER" | "UPLOAD" | "DOWNLOAD";
  STRING              requester_peer_id;
  NUMBER              expires;
  reservation_status  status;
} cs_resource_status;
```

The description of the attributes is as follows:

– overlay_id indicates the overlay identification that the CS resource is allocated;

– virtual_peer_id indicates the identification used by the CS in participating as a peer in the overlay network;

– action_type indicates the type of action performed by the CS;

– requester_peer_id indicates the identification of a peer using the resource of the CS – the attribute is not used when there is no specific peer is involved in CS resource allocation;

– expires indicates the expiration time in minutes of the CS resource;

– status indicates the amount of resources of that CS that has been allocated – it is the object of the reservation_status (refer to clause 9.1.4) element.

9.1.16 RS resource allocation status element

The RS resource allocation status element identifies the amount of resources of RS that has been allocated. The generic definition of the RS resource allocation status element is as follows.

```
Object {
  STRING              relay_instance_id;
  STRING              requester_peer_id;
  NUMBER              expires;
  network_address     rs_address;
  reservation_status  status;
} rs_resource_status;
```

The description of the attributes is as follows.

– relay_instance_id indicates the relay instance identification;

– requester_peer_id indicates the identification of a peer using the RS resource;

– expires indicates the expiration time in minutes of the RS resource;

– rs_address indicates the network address and port of the RS – it is the object of the network_address (refer to clause 9.1.6) element.

– status indicates the amount of RS resources that has been allocated – it is the object of the reservation_status (refer to clause 9.1.4) element.

9.1.17 List of resource allocation status element

The list of resource allocation status elements identifies the list of every resource allocation status while acting as the CS/RS. The generic definition of the list of resource allocation status elements is as follows.

```
Object {
  cs_resource_status      [list_CS_status];
  rs_resource_status      [list_RS_status];
} all_resource_status;
```

The description of the attributes is as follows:

– list_CS_status indicates the list of every resource allocation status acting as the CS – it is the object of the cs_resource_status (refer to clause 9.1.15) element;

– list_RS_status indicates the list of every resource allocation status acting as the RS – it is the object of the rs_resource_status (refer to clause 9.1.16) element.

9.1.18 Resource utilization element

The resource utilization element identifies the utilization of resource that the CS/RS is sharing. The generic definition of the resource utilization element is as follows.

```
Object {
  NUMBER      start_timestamp;
  NUMBER      end_timestamp;
  NUMBER      storage_usage;
  NUMBER      upload_traffic;
  NUMBER      download_traffic;
  NUMBER      uplink_bandwidth;
  NUMBER      downlink_bandwidth;
  NUMBER      upload_connection;
  NUMBER      download_connection;
} utilization_status;
```

The description of the attributes is as follows:

– start_timestamp indicates the start time of the utilization check;

– end_timestamp indicates the end time of the utilization check;

– storage_usage indicates the amount of the storage being used – it is used to check whether the reserved storage is sufficient – this attribute pertains to the CS;

– upload_traffic indicates the upload network traffic volume processed;

– download_traffic indicates the download network traffic volume processed;

– uplink_bandwidth indicates the uplink bandwidth used – it is used to check whether the reserved uplink bandwidth is sufficient;

– downlink_bandwidth indicates the downlink bandwidth used – it is used to check whether the reserved downlink bandwidth is sufficient;

– upload_connection indicates the number of the connection used in uploading traffic;
– download_connection indicates the number of the connection used in downloading traffic.

9.1.19 Peer list element

The peer list element identifies the list of peers. The generic definition of the peer list element is as follows.

```
Object {
  STRING        overlay_id;
  STRING        [peer_id];
} peerlist;
```

The description of the attributes is as follows.

– *overlay_id* indicates the overlay identifier that the list of peers is participating;
– *peer_id* indicates the list of peer identifier.

9.2 Message format

This clause specifies messages for the ORCP.

9.2.1 ORCP_REGISTER_NEW

ORCP_REGISTER_NEW is sent by the CS/RS to the OMS in order to register itself for sharing its resources.

9.2.1.1 Request

The request message format for ORCP_REGISTER_NEW is shown in Table 1.

Table 1 – Request message format for ORCP_REGISTER_NEW

Method	POST
URI	http://{OMS_ADDRESS}[a)]/oms/resource-pool/
Body	resource_registration (refer to clause 9.1.7)
[a)] {OMS_ADDRESS} refers to the FQDN address of OMS.	

An example hypertext transfer protocol (HTTP) request message for ORCP_REGISTER_NEW is as follows.

```
POST /oms/resource-pool HTTP/1.1
Host: www.example_oms.com
Content-Length: 527
Content-Type: application/json
Accept: application/json
{
    "resource_registration" : {
        "type" : "CS",
        "cs_url" : "http://www.example_cs.com/resources/",
        "address" : {
            "address" : "10.10.10.1",
            "port" : 33
```

```
            },
            "expires" : 1600,
            "resource_capa" : {
                "max_storage_size" : 265,
                "max_uplink_bandwidth" : 100,
                "max_downlink_bandwidth" : 100,
                "max_num_connection" : 100,
                "max_num_overlay_network" : 10,
            }
        }
    }
```

9.2.1.2 Response

The response to ORCP_REGISTER_NEW has response code to indicate the result. Table 2 lists response codes and semantics for ORCP_REGISTER_NEW. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 2 – Response code for ORCP_REGISTER_NEW

Response code and semantics		Body
200	OK The request is accepted and registration succeeded.	resource_registration_response (refer to clause 9.1.8)
401	Unauthorized The request requires user authentication. CS/RS may repeat the request with suitable authorization in the HTTP header.	N/A
500	Internal Server Error The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)
501	Not Implemented The request is denied when OMS does not support ORCP.	N/A

Upon 200 OK response, the received information is stored and identified by the following URIs.

http://{OMS_ADDRESS}/oms/resource-pool/{RESOURCE_ID}

NOTE – {OMS_ADDRESS} refers to the fully qualified domain name (FQDN) address of an OMS, and {RESOURCE_ID} refers to the ID of the resource of the CS/RS.

An example HTTP response message for ORCP_REGISTRATION is as follows.

```
HTTP/1.1 200 OK
Content-Length: 221
Content-Type: application/json
{
    "resource_id" : "abcd1234",
    "expires" : 1600,
    "period_keepalive" : 30,
    "period_utilization_status" : 30,
    "period_peerlist: 200
}
```

9.2.2 ORCP_REGISTER_UPDATE

ORCP_REGISTRATION_UPDATE is initiated by the CS/RS to update the resource status.

9.2.2.1 Request

The request message format for ORCP_REGISTER_UPDATE is shown in Table 3.

Table 3 – Request message format for ORCP_REGISTER_UPDATE

Method	PUT
URI	http://{OMS_ADDRESS} [a]/oms/resource-pool/{RESOURCE_ID} [b]
Body	registration_update (refer to clause 9.1.9)
[a] {OMS_ADDRESS} refers to the FQDN address of OMS. [b] {RESOURCE_ID} refers to the ID of resource of either CS or RS.	

An example HTTP request message for ORCP_REGISTER_UPDATE is as follows.

```
PUT /oms/resource-pool/abcd1234 HTTP/1.1
Host: www.example_oms.com
Content-Length: 368
Content-Type: application/json
Accept: application/json
{
    "registation_update" : {
        "type" : "CS",
        "expires" : 1600,
        "resource_capa" : {
            "max_storage_size" : 1285,
            "max_uplink_bandwidth" : 90,
            "max_downlink_bandwidth" : 80,
            "max_num_connection" : 50,
            "max_num_overlay_network" : 7,
        }
    }
}
```

9.2.2.2 Response

The response has response code to indicate the result. Table 4 lists response codes and semantics for ORCP_REGISTER_UPDATE. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 4 – Response code for ORCP_REGISTER_UPDATE

Response code and semantics		Body
200	OK The request is accepted and update succeeded.	N/A
401	Unauthorized The request requires user authentication. CS/RS may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Error The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

9.2.3 ORCP_REGISTER_REMOVE

ORCP_REGISTER_REMOVE is initiated by the CS/RS to indicate its deregistration.

9.2.3.1 Request

The request message format for ORCP_REGISTER_REMOVE is shown in Table 5. The request does not include any data in the message body.

Table 5 – Request message format for ORCP_REGISTER_REMOVE

Method	DELETE
URI	http://{OMS_ADDRESS} [a]/oms/resource-pool/{RESOURCE_ID} [b]
Body	N/A
[a] {OMS_ADDRESS} refers to the FQDN address of OMS. [b] {RESOURCE_ID} refers to the ID of resource of either CS or RS.	

9.2.3.2 Response

The response to ORCP_REGISTER_REMOVE has response code to indicate the result. Table 6 lists response codes and semantics for ORCP_REGISTER_REMOVE. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 6 – Response code for ORCP_REGISTER_REMOVE

Response code and semantics		Body
200	OK The request is accepted and CS/RS deregistration has succeeded.	N/A
401	Unauthorized The request requires user authentication. CS/RS may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Error The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

9.2.4 ORCP_RESERVE_NEW

ORCP_RESERVE_NEW is initiated by the OMS to reserve the resource of the relevant CS/RS.

9.2.4.1 Request

The request message format for ORCP_RESERVE_NEW is shown in Table 7.

Table 7 – Request message format for ORCP_RESERVE_NEW

Method	POST
URI	http://{CSRS_ADDRESS} a)/resources
Body	overlay_resource_reservation (refer to clause 9.1.10)
a) {CSRS_ADDRESS} refers to the FQDN address of either CS or RS.	

An example HTTP request message for ORCP_RESERVE_NEW is as follows.

```
POST /resources HTTP/1.1
Host: www.example_orcp.com
Content-Length: 628
Content-Type: application/ json
Accept: application/ json
{
    "overlay_resource_reservation" : {
        "index_url" : "http://www.example_ixs.com/ixs/example_channel",
        "resource_id" : "abc1234",
        "auth" : {
            "closed" : "NO"
        },
        "action_type" : "PEER",
        "require" : {
            "storage_size" : 1024,
            "uplink_bandwidth" : 50,
            "downlink_bandwidth" : 50,
            "num_connection" : 5
        },
        "leave" : {
            "timeout" : 1024,
            "num_seeder" : 100
        }
    }
}
```

9.2.4.2 Response

The response to ORCP_RESERVE_NEW has response code to indicate the result. Table 8 lists response codes and semantics for ORCP_RESERVE_NEW. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 8 – Response code for ORCP_RESERVE_NEW

Response code and semantics		Body
200	OK The request is accepted and resource reservation has succeeded.	reservation_response (refer to clause 9.1.11)
401	Unauthorized The request requires user authentication. OMS may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Error The request is denied for the following reason.	reservation_error (refer to clause 9.1.12)

Upon 200 OK response, the received information is stored and identified by the following URIs.

http://{CSRS_ADDRESS}/resources/{RESOURCE_ID}

NOTE – {CSRS_ADRESS} refers to the FQDN address of the CS/RS, and {RESOURCE_ID} has the same value of *resource_id* embedded in the request message.

An example HTTP response message for ORCP_RESERVE_NEW is as follows.

```
HTTP/1.1 200 OK
Content-Length: 130
Content-Type: application/json
{
    "virtual_peer_id"  : "vp_abcd1235",
    "expires"  : 1024
}
```

9.2.5 ORCP_RESERVE_UPDATE

ORCP_RESERVE_UPDATE is initiated by the OMS to update the reserved resource of the relevant CS/RS.

9.2.5.1 Request

The request message format for ORCP_RESERVE_UPDATE is shown in Table 9.

Table 9 – Request message format for ORCP_RESERVE_UPDATE

Method	PUT
URI	http://{CSRS_ADDRESS}[a)]/resources/{OVERLAY_RESOURCE_ID}[b)]
Body	reservation_update (refer to clause 9.1.13)
a) {CSRS_ADRESS} refers to the FQDN address of either CS or RS. b) {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS or the identifier of relay instance of RS.	

An example HTTP request message for ORCP_RESERVE_UPDATE is as follows.

```
PUT /resources/vp_abcd1235 HTTP/1.1
Host: www.example_orcp.com
Content-Length: 376
Content-Type: application/json
Accept: application/json
{
    "reservation_update" : {
        "require" : {
            "storage_size" : 624,
            "uplink_bandwidth" : 25,
            "downlink_bandwidth" : 25,
            "num_connection" : 3
        },
        "leave" : {
            "timeout" : 624,
            "num_seeder" : 50
        }
    }
}
```

9.2.5.2 Response

The response tor ORCP_RESERVE_UPDATE has response code to indicate the result. Table 10 lists response codes and semantics ORCP_RESERVE_UPDATE. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 10 – Response code for ORCP_RESERVE_UPDATE

Response code and semantics		Body
200	OK The request is accepted and resource reservation update has succeeded.	N/A
401	Unauthorized The request requires user authentication. OMS may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Error The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

9.2.6 ORCP_RESERVE_REMOVE

ORCP_RESERVE_REMOVE is initiated by the OMS to release the reserved overlay resource.

9.2.6.1 Request

The request message format for ORCP_RESERVE_REMOVE is shown in Table 11. The request does not include any data in the message body.

Table 11 – Request message format for ORCP_RESERVE_REMOVE

Method	DELETE
URI	http://{CSRS_ADDRESS}[a]/resources/{OVERLAY_RESOURCE_ID}[b]
Body	N/A
[a] {CSRS_ADDRESS} refers to the FQDN address of either CS or RS. [b] {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS or the identifier of relay instance of RS.	

9.2.6.2 Response

The response to ORCP_RESERVE_REMOVE has response code to indicate the result. Table 12 lists response codes and semantics for ORCP_RESERVE_REMOVE. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 12 – Response code for ORCP_RESERVE_REMOVE

Response code and semantics		**Body**
200	OK The request is accepted and allocated resource is released.	N/A
401	Unauthorized The request requires user authentication. OMS may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Error The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

9.2.7 ORCP_ALLOCATE_NEW

ORCP_ALLOCATE_NEW is initiated by peer to allocate an overlay resource.

9.2.7.1 Request

The request message format for ORCP_ALLOCATE_NEW is shown in Table 13.

Table 13 – Request message format for ORCP_ALLOCATE_NEW

Method	POST
URI	http://{OMS_ADDRESS}[a]/oms/resources
Body	reservation (refer to clause 9.1.10)
[a] {OMS_ADDRESS} refers to the FQDN address of OMS.	

An example HTTP request message for ORCP_ALLOCATE_NEW is as follows.

```
POST /oms/resources HTTP/1.1
Host: www.example_oms.com
Content-Length: 628
Content-Type: application/json
Accept: application/json
{
    "reservation" : {
        "index_url" : "http://www.example_ixs.com/ixs/ch1234",
        "auth" : {
            "closed" : "YES",
            "key" : "1234567abc"
        },
        "requester_peer_id" : "abcd1234",
        "action_type" : "DOWNLOAD",
        "notification_address" : "mailto:someone@peer.com",
        "require" : {
            "storage_size" : 1024,
            "uplink_bandwidth" : 50,
            "downlink_bandwidth" : 50,
            "num_connection" : 5
        },
        "leave" : {
            "timeout" : 1024,
            "completed" : TRUE
        }
    }
}
```

9.2.7.2 Response

The response to ORCP_ALLOCATE_NEW has response code to indicate the result. Table 14 lists response codes and semantics for ORCP_ALLOCATE_NEW. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 14 – Response code for ORCP_ALLOCATE_NEW

Response code and semantics		Body
200	OK The request is accepted and resource allocation has succeeded.	Reservation_response (refer to clause 9.1.11)
401	Unauthorized The request requires user authentication. Peer may repeat the request with suitable authorization in the HTTP header.	N/A
500	Internal Server Error The request is denied for the following reason.	Reservation_error (refer to clause 9.1.12)

Upon 200 OK response, the received information is stored and identified by the following URIs.

– http://{OMS_ADDRESS}/oms/resources/{RESOURCE_ID}/{OVERLAY_RESOURCE_ID}

– http://{OMS_ADDRESS}/oms/peer/{PEER_ID}/resources/{OVERLAY_RESOURCE_ID}

NOTE 1 – {OMS_ADDRESS} refers to the FQDN address of OMS, {RESOURCE_ID} refers to the ID of resource of either CS or RS.

NOTE 2 – {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS or the identifier of relay instance of RS.

NOTE 3 – {PEER_ID} refers to the ID of the requesting peer.

An example HTTP response message for ORCP_ALLOCATE_NEW is as follows.

```
HTTP/1.1 200 OK
Content-Length: 122
Content-Type: application/json
{
    "resource_id" : "abc12345",
    "expires"  : 1024,
    "link" : "ftp://20.20.20.3/download"
}
```

9.2.8 ORCP_ALLOCATE_UPDATE

ORCP_ALLOCATE_UPDATE is initiated by peer to update the allocated overlay resource.

9.2.8.1 Request

The request message format for ORCP_ALLOCATE_UPDATE is shown in Table 15.

Table 15 – Request message format for ORCP_ALLOCATE_UPDATE

Method	PUT
URI	http://{OMS_ADDRESS}[a]/oms/resources/{RESOURCE_ID}[b] /{OVERLAY_RESOURCE_ID}[c]
Body	reservation_update (refer to clause 9.1.13)

[a] {OMS_ADDRESS} refers to the FQDN address of OMS.

[b] {RESOURCE_ID} refers to the ID of resource of either CS or RS.

[c] {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS or the identifier of relay instance of RS.

An example HTTP request message for ORCP_ALLOCATE_UPDATE is as follows.

```
PUT /oms/resources/abc12345/vp_abcd1235 HTTP/1.1
Host: www.example_oms.com
Content-Length: 376
Content-Type: application/json
Accept: application/json
{
    "reservation_update" : {
        "require" : {
```

```
                "storage_size" : 624,
                "uplink_bandwidth" : 25,
                "downlink_bandwidth" : 25,
                "num_connection" : 3
            },
            "leave" : {
                "timeout" : 624,
                "num_seeder" : 50
            }
        }
    }
```

9.2.8.2 Response

The response to ORCP_ALLOCATE_UPDATE has response code to indicate the result. Table 16 lists response codes and semantics for ORCP_ALLOCATE_UPDATE. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 16 – Response code for ORCP_ALLOCATE_UPDATE

Response code and semantics		Body
200	OK The request is accepted and allocation update has succeeded.	N/A
401	Unauthorized The request requires user authentication. Peer may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Failure The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

9.2.9 ORCP_ALLOCATE_REMOVE

ORCP_ALLOCATE_REMOVE is sent to OMS to overlay resource to release the relevant overlay resource.

9.2.9.1 Request

The request message format for ORCP_ALLOCATE_REMOVE is shown in Table 17. The request does not include any data in the message body.

Table 17 – Request message format for ORCP_ALLOCATE_REMOVE

Method	DELETE
URI	http://{OMS_ADDRESS}[a]/oms/resources/{RESOURCE_ID}[b] /{OVERLAY_RESOURCE_ID}[c]
Body	N/A

[a] {OMS_ADDRESS} refers to the FQDN address of OMS.

[b] {RESOURCE_ID} refers to the ID of resource of either CS or RS.

[c] {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS and the identifier of relay instance of RS.

9.2.9.2 Response

The response to ORCP_ALLOCATE_REMOVE has response code to indicate the result. Table 18 lists response codes and semantics for ORCP_ALLOCATE_REMOVE. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 18 – Response code for ORCP_ALLOCATE_REMOVE

Response code and semantics		**Body**
200	OK The request is accepted and resource is successfully released.	N/A
401	Unauthorized The request requires user authentication. Peer may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Failure The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

9.2.10 ORCP_QUERY_STATUS

ORCP_QUERY_STATUS is used to retrieve the list of total resource allocation status for every overlay network.

9.2.10.1 Request

The request message format for ORCP_QUERY_STATUS is shown in Table 19. The request message does not include any data in the message body.

Table 19 – Request message format for ORCP_QUERY_STATUS

Method	GET
URI	http://{CSRS_ADDRESS}[a]/resources
Body	N/A

[a] {CSRS_ADDRESS} refers to the FQDN address of CS/RS.

9.2.10.2 Response

The response to ORCP_QUERY_STATUS has response code to indicate the result. Table 20 lists response codes and semantics for ORCP_QUERY_STATUS. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 20 – Response code for ORCP_QUERY_STATUS

Response code and semantics		Body
200	OK The request is accepted and resource status is returned.	all_resource_status (refer to clause 9.1.17)
401	Unauthorized The request requires user authentication. The requesting entity may repeat the request with suitable authorization in the HTTP header.	N/A
500	Internal Server Failure The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

An example HTTP response message for ORCP_QUERY_STATUS is as follows.

```
HTTP/1.1 200 OK
Content-Length: 1787
Content-Type: application/json
{
   "list_CS_status"  : [
   {
      "overlay_id" : "12ekd4kd8",
      "virtual_peer_id"  : " vp1csabc12345",
      "action_type" : "PEER",
      "requester_peer_id" : "8djdhd ",
      "expires" : 100,
      "status" : {
         "storage_size" : 624,
         "upload_traffic" : 201,
         "download_traffic" : 101,
         "uplink_bandwidth" : 25,
         "downlink_bandwidth" : 25,
         "num_connection" : 3
      }
   },
   {
      "overlay_id" : "18old4k80",
      "virtual_peer_id"  : " vp2csabc12345",
      "action_type" : "DOWNLOAD",
      "requester_peer_id" : "8djd20",
      "expires" : 60,
```

```
   "status" : {
      "storage_size" : 100,
      "upload_traffic" : 31,
      "download_traffic" : 251,
      "uplink_bandwidth" : 10,
      "downlink_bandwidth" : 10,
      "num_connection" : 2
   }
}],
"list_RS_status"  : [
{
   "relay_instance_id" : " ri1csabc12345",
   "requester_peer_id" : "8djd18",
   "expires" : 100,
   "rs_address" : {
      "address" : "10.10.10.3",
      "port" : 33
},
"resource_status" : {
      "upload_traffic" : 100,
      "download_traffic" : 31,
      "uplink_bandwidth" : 35,
      "downlink_bandwidth" : 35,
      "num_connection" : 4
   }
},
{
   "relay_instance_id" : " ri2csabc12345",
   "requester_peer_id" : "5kid18",
   "expires" : 60,
   "rs_address" : {
   "address" : "10.10.10.3",
   "port" : 34
},
"resource_status" : {
   "upload_traffic" : 300,
   "download_traffic" : 131,
   "uplink_bandwidth" : 21,
   "downlink_bandwidth" : 21,
   "num_connection" : 6
  }
}]
```

```
}
```

9.2.11 ORCP_QUERY_CS_STATUS

ORCP_QUERY_CS_STATUS is used to retrieve resource allocation status for the relevant CS.

9.2.11.1 Request

The request message format for ORCP_QUERY_CS_STATUS is shown in Table 21. The request message does not include any data in the message body.

Table 21 – Request message format for ORCP_QUERY_CS_STATUS

Method	GET
URI	http://{CS_ADDRESS}[a]/resources/{VPID}[b]
Body	N/A
[a] {CS_ADDRESS} refers to the FQDN address of CS. [b] {VPID} refers to the virtual peer identification used by CS.	

9.2.11.2 Response

The response to ORCP_QUERY_CS_STATUS has response code to indicate the result. Table 22 lists response codes and semantics for ORCP_QUERY_CS_STATUS. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 22 – Response code for ORCP_QUERY_CS_STATUS

Response code and semantics		Body
200	OK The request is accepted and CS resource status is returned.	cs_resource_status (refer to clause 9.1.15)
401	Unauthorized The request requires user authentication. The requesting entity may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS with the requested identifier.	N/A
500	Internal Server Failure The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

An example HTTP response message for ORCP_QUERY_CS_STATUS is as follows.

```
HTTP/1.1 200 OK
Content-Length: 424
Content-Type: application/json
{
   "overlay_id" : "12ekd4kd8",
   "virtual_peer_id"  : " vp1csabc12345",
   "action_type" : "PEER",
   "requester_peer_id" : "8djdhd ",
   "expires" : 100,
   "resource_status" : {
```

```
            "storage_size" : 100,
            "upload_traffic" : 31,
            "download_traffic" : 251,
            "uplink_bandwidth" : 10,
            "downlink_bandwidth" : 10,
            "num_connection" : 2
        }
    }
```

9.2.12 ORCP_QUERY_RS_STATUS

ORCP_QUERY_RS_STATUS is sent to RS to provide resource allocation status for the relevant overlay network.

9.2.12.1 Request

The request message format for ORCP_QUERY_RS_STATUS is shown in Table 23. The request message does not include any data in the message body.

Table 23 – Request message format for ORCP_QUERY_RS_STATUS

Method	GET
URI	http://{RS_ADDRESS}[a]/resources/{RSID}[b]
Body	N/A
[a] {RS_ADDRESS} refers to the FQDN address of RS. [b] {RSID} refers to the relay instance identification used by RS.	

9.2.12.2 Response

The response to ORCP_QUERY_RS_STATUS has response code to indicate the result. Table 24 lists response codes and semantics for ORCP_QUERY_RS_STATUS. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 24 – Response code for ORCP_QUERY_RS_STATUS

Response code and semantics		Body
200	OK The request is accepted and RS resource status is returned.	rs_resource_status (refer to clause 9.1.16)
401	Unauthorized The request requires user authentication. The requesting entity may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no RS with the requested identifier.	N/A
500	Internal Server Failure The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

An example HTTP response message for ORCP_QUERY_RS_STATUS is as follows.

```
HTTP/1.1 200 OK
Content-Length: 404
```

```
Content-Type: application/json
{
   "relay_instance_id" : " ri1csabc12345",
   "requester_peer_id" : "8djd18",
   "expires" : 32,
    "rs_address" : {
        "address" : "10.10.10.2",
        "port" : 35
     },
     "resource_status" : {
         "upload_traffic" : 200,
         "download_traffic" : 231,
         "uplink_bandwidth" : 41,
         "downlink_bandwidth" : 31,
         "num_connection" : 10
      }
}
```

9.2.13 ORCP_QUERY_STATUS_PEER

ORCP_QUERY_STATUS_PEER is used to retrieve the list of overlay resources allocated by the requesting peer.

9.2.13.1 Request

The request message format for ORCP_QUERY_STATUS_PEER is shown in Table 25. The request message does not include any data in the message body.

Table 25 – Request message format for ORCP_QUERY_STATUS_PEER

Method	GET
URI	http://{OMS_ADDRESS} a)/oms/peer/{PEER_ID} b)/resources
Body	N/A
a) {OMS_ADDRESS} refers to the FQDN address of OMS. b) {PEER_ID} refers to the ID of the requesting peer.	

9.2.13.2 Response

The response to ORCP_QUERY_STATUS_PEER has response code to indicate the result. Table 26 lists response codes and semantics for ORCP_QUERY_STATUS_PEER. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 26 – Response code for ORCP_QUERY_STATUS_PEER

Response code and semantics		Body
200	OK The request is accepted and all overlay resource status allocated to the relevant peer is returned.	all_resource_status (refer to clause 9.1.17)
401	Unauthorized The request requires user authentication. The requesting entity may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no peer with the requested identifier.	N/A
500	Internal Server Failure The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

An example HTTP response message for ORCP_QUERY_STATUS_PEER is as follows.

```
HTTP/1.1 200 OK
Content-Length: 1209
Content-Type: application/json
{
   "list_CS_status"  : [
   {
      "overlay_id" : "12ekd4kd8",
      "virtual_peer_id"  : " vp1csabc12345",
      "action_type" : "PEER",
      "expires" : 100,
      "status" : {
         "storage_size" : 100,
         "upload_traffic" : 201,
         "download_traffic" : 101,
         "uplink_bandwidth" : 25,
         "downlink_bandwidth" : 25,
         "num_connection" : 3
      }
   },
   {
      "overlay_id" : "18old4k80",
      "virtual_peer_id"  : " vp2csabc12345",
      "action_type" : "UPLOAD",
      "expires" : 260,
      "status" : {
         "storage_size" : 100,
         "upload_traffic" : 31,
         "download_traffic" : 251,
```

```
            "uplink_bandwidth" : 10,
            "downlink_bandwidth" : 10,
            "num_connection" : 2
         }
      }],
      "list_RS_status"  : [
      {
         "relay_instance_id" : " ri1csabc12345",
         "expires" : 5,
         "rs_address" : {
            "address" : "10.10.10.3",
            "port" : 33
         },
         "resource_status" : {
            "upload_traffic" : 100,
            "download_traffic" : 31,
            "uplink_bandwidth" : 35,
            "downlink_bandwidth" : 35,
            "num_connection" : 2
         }
      }]
   }
```

9.2.14 ORCP_PROBE_STATUS

ORCP_PROBE_STATUS is used to discover the fault of CS/RS.

9.2.14.1 Request

The request message format for ORCP_PROBE_STATUS is shown in Table 27. The request message does not include any data in the message body.

Table 27 – Request message format for ORCP_PROBE_STATUS

Method	GET
URI	http://{OMS_ADDRESS}[a]/oms/resources/{RESOURCE_ID}[b] /{OVERLAY_RESOURCE_ID}[c]
Body	N/A

[a] {OMS_ADDRESS} refers to the FQDN address of OMS.
[b] {RESOURCE_ID } refers to the ID of the resource.
[c] {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS or the identifier of relay instance of RS.

9.2.14.2 Response

The response to ORCP_PROBE_STATUS has response code to indicate the result. Table 28 lists response codes and semantics for ORCP_PROBE_STATUS. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 28 – Response code for ORCP_PROBE_STATUS

Response code and semantics		Body
200	OK The request is accepted and will start checking CS/RS functional status.	N/A
401	Unauthorized The request requires user authentication. The Peer may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Error The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

9.2.15 ORCP_REPORT_USAGE

ORCP_REPORT_USAGE is initiated by CS/RS to report its resource utilization status. OMS repeats this procedure after timeout of period_utilization_status in the ORCP_REGISTER_NEW response message.

9.2.15.1 Request

The request message format for ORCP_REPORT_USAGE is shown in Table 29.

Table 29 – Request message format for ORCP_REPORT_USAGE

Method	GET
URI	http://{OMS_ADDRESS}[a]/oms/resources/{RESOURCE_ID}[b] /{OVERLAY_RESOURCE_ID}[c]
Body	utilization_status (refer to clause 9.1.18)

[a] {OMS_ADDRESS} refers to the FQDN address of OMS.
[b] {RESOURCE_ID} refers to the ID of resource of either CS or RS.
[c] {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS or the identifier of relay instance of RS.

An example HTTP request message for ORCP_REPORT_USAGE is as follows.

```
PUT /oms/resources/ abc12345/ vp1csabc12345 HTTP/1.1
Host: www.example_oms.com
Content-Length: 576
Content-Type: application/json
Accept: application/json
{
   "utilization_status" {
      "start_timestamp"     : 20160101130110,
      "end_timestamp"       : 20160101130140,
      "storage_usage"       : 150,
      "upload_traffic"      :  100,
      "download_traffic"    : 55,
```

```
        "uplink_bandwidth"    : 10,
        "downlink_bandwidth"  : 10,
        "upload_connection"   : 2,
        "download_connection  : 3
      }
  }
```

9.2.15.2 Response

The response to ORCP_REPORT_USAGE has response code to indicate the result. Table 30 lists response codes and semantics for ORCP_REPORT_USAGE. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 30 – Response code for ORCP_REPORT_USAGE

Response code and semantics		Body
200	OK The request is accepted.	N/A
401	Unauthorized The request requires user authentication. CS/RS may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Failure The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

9.2.16 ORCP_REQUEST_PEERLIST

ORCP_REQUEST_PEERLIST is initiated by the CS/RS to the OMS in order to request a list of peers. CS/RS repeats this procedure after timeout of period_peerlist in ORCP_REGISTER_NEW Response message.

9.2.16.1 Request

The request message format for ORCP_REQUEST_PEERLIST is shown in Table 31. The request does not include any data in the message body.

Table 31 – Request message format for ORCP_REQUEST_PEERLIST

Method	GET
URI	http://{OMS_ADDRESS} [a]/oms/resources/{RESOURCE_ID} [b] /{OVERLAY_RESOURCE_ID}[c]
Body	N/A

[a] {OMS_ADDRESS} refers to the FQDN address of OMS.

[b] {RESOURCE_ID} refers to the ID of resource of either CS or RS.

[c] {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS or the identifier of relay instance of RS.

9.2.16.2 Response

The response to ORCP_REQUEST_PEERLIST has response code to indicate the result. Table 32 lists response codes and semantics for ORCP_REQUEST_PEERLIST. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 32 – Response code for ORCP_REQUEST_PEERLIST

Response code and semantics		Body
200	OK The request is accepted.	peerlist (refer to clause 9.1.19)
401	Unauthorized The request requires user authentication. CS/RS may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Error The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

An example HTTP response message for ORCP_REQUEST_PEERLIST is as follows.

```
HTTP/1.1 200 OK
Content-Length: 209
Content-Type: application/json
{
   "overlay_id" : "12ekd4kd8",
   "peer_id" : [ "1h2md20", "91did97", "91pad17" ]
}
```

9.2.17 ORCP_REPORT_PEERLIST

ORCP_REPORT_PEERLIST is initiated by the CS/RS to report the list of peers that have made connectivity with the CS/RS.

9.2.17.1 Request

The request message format for ORCP_REPORT_PEERLIST is shown in Table 33.

Table 33 – Request message format for ORCP_REPORT_PEERLIST

Method	GET
URI	http://{OMS_ADDRESS} a)/oms/resources/{RESOURCE_ID} b) /{OVERLAY_RESOURCE_ID} c)
Body	peerlist (refer to clause 9.1.19)

a) {OMS_ADDRESS} refers to the FQDN address of OMS.

b) {RESOURCE_ID} refers to the ID of resource of either CS or RS.

c) {OVERLAY_RESOURCE_ID} refers to either the identifier of virtual peer of CS or the identifier of relay instance of RS.

An example HTTP request message for ORCP_REPORT_PEERLIST is as follows.

```
PUT /oms/resources/ abc12345/ vp1csabc12345 HTTP/1.1
Host: www.example_oms.com
Content-Length: 209
Content-Type: application/json
Accept: application/json
{
   "overlay_id" : "12ekd4kd8",
   "peer_id" : [ "1h2md20", "91pad17" ]
}
```

9.2.17.2 Response

The response to ORCP_REPORT_PEERLIST has response code to indicate the result. Table 34 lists response codes and semantics for ORCP_REPORT_PEERLIST. The response does not include any data in the message body. This Recommendation follows [IETF RFC 7231] for other response codes.

Table 34 – Response code for ORCP_REPORT_PEERLIST

Response code and semantics		Body
200	OK The request is accepted.	N/A
401	Unauthorized The request requires user authentication. CS/RS may repeat the request with suitable authorization in the HTTP header.	N/A
404	Not Found The request is denied because there is no CS/RS with the requested identifier.	N/A
500	Internal Server Error The request is denied for the following reason.	failure_reason (refer to clause 9.1.14)

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