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SERIES Q: SWITCHING AND SIGNALLING, AND
ASSOCIATED MEASUREMENTS AND TESTS

Protocols and signalling for peer-to-peer communications

Hybrid peer-to-peer communications: Peer protocol

Recommendation ITU-T Q.4102

ITU-T

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Recommendation ITU-T Q.4102

Hybrid peer-to-peer communications: Peer protocol

Summary

Recommendation ITU-T Q.4102 describes the peer protocol for communication among peers. The peer protocol enables peers to organize a tree-based overlay network in a hybrid peer-to-peer network and distribute data over the overlay network. This Recommendation also specifies the connection types among peers, resource elements types used in the message header, protocol messages exchanged among peers and information flows for describing behaviours of peer.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Q.4102	2022-02-13	11	11.1002/1000/14923

Keywords

Hybrid peer-to-peer, peer protocol, tree-based overlay network.

* 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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Recommendation ITU-T Q.4102

Hybrid peer-to-peer communications: Peer protocol

1 Scope

This Recommendation describes peer protocol for tree-based overlay network in hybrid peer-to-peer (HP2P) communications as follows:

- connection types between peers;
- resource elements of protocol messages;
- protocol messages and its parameters;
- information flows for describing behaviours of peer.

2 References

The following ITU-T Recommendations and other references contain provisions that, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T Q.4100] Recommendation ITU-T Q.4100 (2020), *Hybrid peer-to-peer communications: Functional architecture*.
- [ITU-T Q.4101] Recommendation ITU-T Q.4101 (2021), *Hybrid peer-to-peer communications: Tree and data recovery procedures*.
- [ITU-T Q.4103] Recommendation ITU-T Q.4103, *Hybrid peer-to-peer (communications: Overlay management protocol*.
- [IETF RFC 7159] IETF RFC 7159 (2014), *The JavaScript Object Notation (JSON) Data Interchange Format*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 buffermap [b-ITU-T X.609]: A map showing the downloading status of fragments comprising a shared content.

3.1.2 corresponding peer [b-ITU-T X.609.4]: A peer that performs an operation on the request received from the requesting peer.

3.1.3 hybrid overlay network [ITU-T Q.4100]: A peer-to-peer overlay network in which participating peers exchange data using the pull and push method. The hybrid overlay network also provides a way to organize and maintain a tree-style path for pushing data to all peers without loops, as well as fetching data from other peers simultaneously.

3.1.4 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.

3.1.5 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.

3.1.6 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.

3.1.7 requesting peer [b-ITU-T X.609.4]: A peer that sends a request to the other corresponding peer.

3.2 Terms defined in this Recommendation

None.

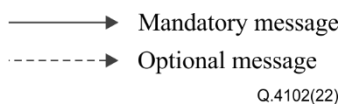
4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

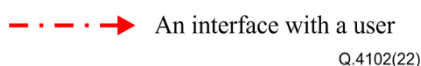
HOMS	Hybrid Overlay Management Server
HP2P	Hybrid Peer-to-Peer
NTP	Network Time Protocol
P2P	Peer-to-Peer

5 Conventions

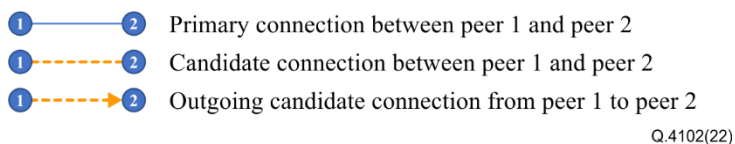
In this Recommendation, message flows among peers to describe the operation of each message and behaviours of peer protocol are drawn with solid arrow lines or dashed arrow lines. The solid arrow line indicates a mandatory message and the dashed arrow line indicates an optional message.



An interface with a user is drawn with a dot dashed line.



The connection between peers is presented by solid lines or dashed lines. A solid line between peers is a primary connection and a dashed line between peers is a candidate connection. A dashed arrow line between peers indicates an outgoing or incoming candidate connection.



In the response message under clause 7.2, *rsp-code* is a combination of the request type for classifying the type of request and the response type for classifying the type of response. For example, *rsp-code* will be 2200 if the request type is "2" and the response type is "200". However, figures under clause 7.2 do not show the exact value of *rsp-code* for ease of understanding about the meaning of the response.

Resource elements in clause 7.1 and fields of message header and extension under clause 7.2 are encoded in JavaScript object notation (JSON) [IETF RFC 7159], and the grammar used in representing objects defined in this Recommendation is as follows:

- "NUMBER", "STRING", "BOOLEAN" and "LIST" are types used to indicate number, string, boolean and list respectively;
- An array of collective values are enclosed in brackets "[]" with values separated by commas ",".

6 Connection types

This clause describes the connections between peers. The concept of a path (primary path / secondary path) described in [ITU-T Q.4100] is defined as a connection in this Recommendation. These connections between peers in a tree-based overlay network are classified as follows:

- **Primary connection:** This connection is established for data broadcasting between peers. A peer in a tree-based overlay network has one or more primary connections for sending and receiving data from other peers. However, it maintains only one primary connection between two identical peers.
- **Candidate connection:** This connection is not used for data broadcasting between peers, but it is established in advance to restore fast in loss of primary connection. When a peer has a problem to send and receive data through the primary connection, it is necessary to replace the old primary connection with the new primary connection immediately. Therefore, when a peer detects a loss of a primary connection, it switches one of the candidate connections to a new primary connection.

7 Resource element types and messages of peer protocol

7.1 Resource elements

This clause specifies the basic resource elements to be used in messages to convey information regarding the operations of peer.

7.1.1 PEER_BUFFERMAP

All peers maintain a caching buffer list for data received from other peers, which consists of a set of caching buffers in the form of a circular queue for each data source. The PEER_BUFFERMAP element includes detailed information about caching buffer list in Table 7-1.

Table 7-1 – PEER_BUFFERMAP resource element

Keyword	Type	Description
buffmaplist	LIST[BUFFERMAP]	<i>buffmaplist</i> includes the list of buffermap information such as source peer id and sequence of data packets described in [ITU-T Q.4101].

7.1.2 BUFFERMAP

The BUFFERMAP element includes detailed information on the caching buffer such as an identifier of source peer and a sequence list of data packets information received from source peer in Table 7-2.

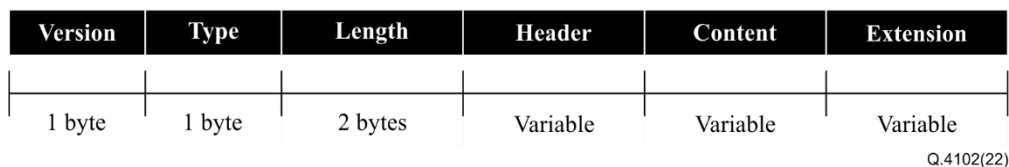
Table 7-2 – BUFFERMAP resource element

Keyword	Type	Description
source-peer-id	STRING	<i>source-peer-id</i> indicates the identifier of the peer who has sent the BROADCAST_DATA request message.
sequence-list	LIST[NUMBER]	<i>Sequence-list</i> includes the list of sequence values in the data packet received through the BROADCAST_DATA request message.

7.2 Messages

This clause describes the messages exchanged between peers to be used in the reference point R2 that is specified in [ITU-T Q.4100] and the header of messages is represented as JavaScript object notation (JSON) [IETF RFC 7159].

Figure 7-1 shows the format and length of the message.

**Figure 7-1 – Message format of peer protocol**

- *version*: this field means the version of the protocol, and the current version is assigned as 0x01.
- *type*: this field means the encoding type of the header, and 0x01 and 0x10 are assigned as type values. The current version is assigned as 0x01. In this case, 0x01 is defined as a text type and 0x10 is defined as a binary encoding type.
- *length*: this field means the length of the header field.
- *header*: this field contains a code that distinguishes whether a message is a request or a response and the necessary parameters for the message code.
- *content*: this field contains content data. The length of the content can be checked through the length value of the *payload* field included in the header.
- *extension*: this field contains private purpose parameters.

The following subclauses describe the message flow between peers, the peer operation related to the message, and the detailed format of the header part of each message.

7.2.1 HELLO_PEER

A peer can initiate overlay network join by exchange of HELLO_PEER request and response message with other peers belonging to the overlay network. Figure 7-2 shows the message flow of HELLO_PEER.

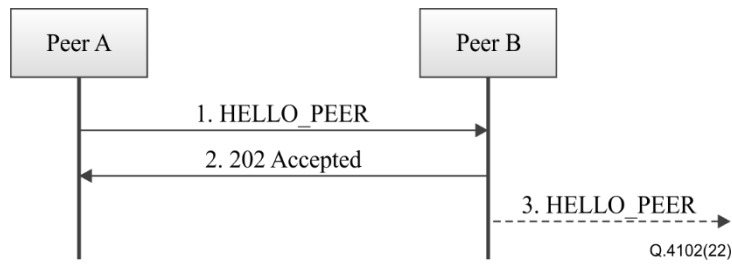


Figure 7-2 – Message flow of HELLO_PEER

- ① When a new peer A wants to join an overlay network, it sends a HELLO_PEER request message to one of the peers (peer B in Figure 7-2) participating in the overlay network.
The list of peers participating in the overlay network is obtained from a hybrid overlay management server (HOMS). At this time, the peer sending a HELLO_PEER request message acts as a requesting peer and the responding peer that interacts with requesting peer acts as a corresponding peer.
- ② Peer B receiving the HELLO_PEER request message firstly checks whether it is acceptable and then processes it if possible. Peer B can then send a 202 (accepted) response which indicates it has received the HELLO_PEER request message.
- ③ Peer B transfers the received HELLO_PEER request message to the acceptable peers connected to their primary connection.
This is determined by considering the maximum number of requesting connections. The maximum number of requesting connections is the same as the value of the *conn_num* field within the HELLO_PEER request message, or 1 is reduced here. The latter is when peer B handles the HELLO_PEER request message.
Peer B forwards the HELLO_PEER request message to the peers with a primary connection relationship if the maximum number of requesting connections is greater than 0. Peer B divides the maximum number of requesting connections by the number of peers in the primary connection relationship and then forwards the HELLO_PEER request message to each peer in the primary connection relationship.

Table 7-3 describes the syntax and semantics of each field in the header of a HELLO_PEER request message.

Table 7-3 – Header format of HELLO_PEER request

Syntax	Description
<pre>{ "req-code ": NUMBER, "req-params": { "operation": { "overlay-id": STRING, "conn_num": NUMBER, "ttl": NUMBER, "recovery": BOOLEAN }, "peer": { "peer-id": STRING,</pre>	– <i>req-code</i> indicates the type of the request message. In case of a HELLO_PEER request message, <i>req-code</i> value is set as 1. – <i>overlay-id</i> indicates an identifier of the overlay network that the new peer wants to participate. – <i>conn_num</i> indicates the number of connections that the new peer wants to establish with other peers. – <i>ttl</i> indicates the number of steps of the message the peer wants to pass on to. The new participating peer specifies the initial ttl value, and the peer receiving the HELLO_PEER message reduces the ttl value by one when forwarding the message.

Table 7-3 – Header format of HELLO_PEER request

Syntax	Description
<pre> "address": STRING, "ticket-id": NUMBER } } }</pre>	– <i>recovery</i> is used when an emergency recovery is needed. If a new peer joins the overlay network for the first time, this field is not used. – <i>peer-id</i> indicates the identifier of the new participating peer. – <i>address</i> indicates network address information of new participating peer that can be accessed by other peers. – <i>ticket-id</i> indicates the ticket-id value for the new participating peer. <i>ticket-id</i>, a value that indicates the order of peer joined to the hybrid overlay network, which is taken from the HOMS defined in [ITU-T Q.4100]. This means a peer with a low ticket-id value has first joined the corresponding overlay network. When recovering from an overlay network problem, a ticket ID plays an important role in preventing a loop by causing the peer with a large ticket ID value to attempt recovery of a broken connection.

Table 7-4 describes the syntax and semantics of each field in the header of a HELLO_PEER response message.

Table 7-4 – Header format of HELLO_PEER response

Syntax	Description
<pre> { "rsp-code": NUMBER }</pre>	– <i>rsp-code</i> indicates which response message is for which request. The <i>rsp-code</i> is a combination of the request type in classifying the type of request and the response type for classifying the type of response. The request type is defined in the <i>req-code</i> in the request message. In case of a HELLO_PEER response message, <i>rsp-code</i> value is set as 1202 if the result of the request is successful. • <i>rsp-code</i> value 1202 is a combination of the request type (1) and response type (202). Response type 202 means 'accepted'. Therefore, <i>rsp-code</i> value 1202 means an 'accepted' response to the HELLO_PEER request message.

7.2.2 ESTAB_PEER

A candidate connection can be established by exchange of an ESTAB_PEER request and response messages. An ESTAB_PEER request message is used by a peer which received a HELLO_PEER request message from a newly joining peer to directly connect to the new peer that wants to join. Figure 7-3 shows the message flows of ESTAB_PEER messages.