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This contribution is the revised text of the draft Recommendation ITU-T X.607.1 | ISO/IEC 14476-4 (ECTP-4), which is submitted for discussion to the 2008 April joint meeting of ITU-T Q.1/17 and JTC1/SC6/WG7.

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

ISO/IEC 14476 consists of the following parts, under the general title Information technology — Enhanced Communications Transport Protocol:

— Part 1: Specification of simplex multicast transport

(ITU-T X.606 | ISO/IEC 14476-1, ECTP-1)

— Part 2: Specification of QoS management for simple multicast transport

(ITU-T X.606.1 | ISO/IEC 14476-2, ECTP-2)

— Part 3: Specification of duplex multicast transport

(ITU-T X.607 | ISO/IEC 14476-3. ECTP-3)

— Part 4: Specification of QoS management for duplex multicast transport

(ITU-T X.607.1 | ISO/IEC 14476-4, ECTP-4)

— Part 5: Specification of N-plex multicast transport

(ITU-T X.608 | ISO/IEC 14476-5, ECTP-5)

— Part 6: Specification of QoS management for N-plex multicast transport

(ITU-T X.608.1 | ISO/IEC 14476-6, ECTP-6)

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INTERNATIONAL STANDARD 14476-4
ITU-T RECOMMENDATION X.607.1

INFORMATION TECHNOLOGY – ENHANCED COMMUNICATIONS TRANSPORT PROTOCOL: SPECIFICATION OF QOS MANAGEMENT FOR DUPLEX MULTICAST TRANSPORT

Summary

This Recommendation | International Standard specifies the Enhanced Communications Transport Protocol (ECTP), which is a transport protocol designed to support Internet multicast applications running over multicast-capable networks. This fourth part of ECTP (ECTP-4) defines the QoS management functions for the duplex multicast transport defined in the third part of ECTP (ECTP-3). This specification describes the following QoS management operations: QoS negotiation, QoS monitoring, and QoS maintenance.

Introduction

This Recommendation | International Standard specifies the Enhanced Communications Transport Protocol (ECTP), which is a transport protocol designed to support Internet multicast applications running over multicast-capable networks. ECTP operates over IPv4/IPv6 networks that have the IP multicast forwarding capability with the help of IGMP and IP multicast routing protocols, as shown in Figure 1. ECTP could possibly be provisioned over UDP.

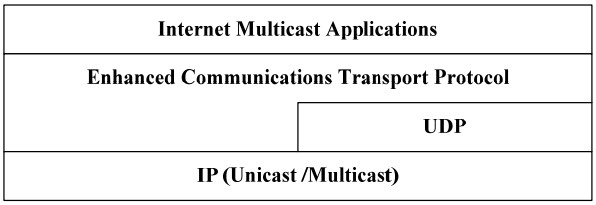


Figure 1 – ECTP Model

ECTP is designed to support tightly controlled multicast connections in simplex, duplex and N-plex applications. ECTP-part 4 QoS management (ITU-T Rec. X.607.1 | ISO/IEC 14476-4) specifies the Quality of Services (QoS) management functionality for stable management in the duplex multicast connection. The QoS management functionality consists of QoS negotiation, QoS monitoring, and QoS maintenance operations. The procedures of reliability control in duplex connection have been defined in ECTP part3 (ITU-T Rec.X607|ISO/IEC 14476-3).

In ECTP-3 duplex multicast connection, the participants are classified into one Transport Connection Owner (TC-Owner) and many Transport Services users (TS-users). TC-Owner will be designated among the TS-users before the connection creation. In the duplex multicast connection, the two types of data transports are supported: multicast data transport from TC-Owner to the all of TS-users and unicast data transport from TS-users to TC-Owner. After the connection is created, TC-Owner can transmit multicast data to the group, whereas each TS-user is allowed to send unicast data to TC-Owner just after it gets a token from the TC-Owner.

For QoS management in the duplex multicast connection, the TC-Owner triggers the connection creation process. Some or all of the enrolled TS-users will participate in the connection and become the designated “active TS-users.” The TS-users who are active at this stage are able to participate in negotiating the desired QoS level for the session. In the duplex multicast connection, TS-users can send the data to TC-Owner, which each TS-user negotiates with TC-Owner for a QoS parameter for backward unicast data channel. TC-Owner proposes the target value of QoS parameter for forward multicast data channel and backward unicast data channel. If QoS negotiation is enabled, each TS-user can propose modified values of QoS parameters for forward multicast data channel and backward unicast data channel. TC-Owner arbitrates these modified values of QoS parameters for two types of data transport. These arbitrated values are delivered to TS-users via subsequent Heartbeat (HB) or Join Confirm (JC) packets, and will be used for QoS monitoring and maintenance. Any enrolled TS-user that is not active at this stage may participate in the connection as a late-joiner, but will have to accept the established QoS level. An active TS-user can leave the connection.

After the connection is created, TC-Owner begins to transmit multicast data and some of TS-users who get a token from TC-Owner can send unicast data to TC-Owner. While the connection is active, TC-Owner monitors the status of the session via feedback control packets from the active TS-users.

TC-Owner may take a range of actions if network problems (such as severe congestion) are indicated by the feedback received from active TS-users. These actions include adjusting the data transmission rate, suspending multicast data transmission temporarily, or in the last resort, terminating the connection.

ECTP part4 QoS management specification can be used by the multicast applications that require supporting various QoS requirements and the corresponding billing/charging models.

1 Scope

This Recommendation | International Standard provides a specification of QoS management for accomplishing desirable QoS for a duplex multicast transport connection. For this purpose, this specification describes the following QoS management operations in duplex multicast transport connection:

a) QoS negotiation

For QoS negotiation, this specification assumes that a desired QoS level for multicast application service can be expressed in terms of a set of QoS parameters. QoS negotiation is performed via exchange of control packets between TC-owner and TS-users for forward multicast data channel and backward unicast data channel. TC-owner proposes the target values of QoS parameters obtained from the application's requirements in order to send the multicast data to TS-user and to receive the unicast data from some sending TS-users, and then each TS-user can propose modified values based on its system requirements and/or network capacity and its application's requirement to receive the multicast data from TC-Owner and to send the unicast data to TC-Owner. TC-Owner arbitrates the modified values proposed by TS-users. Target values for QoS parameters can be used as input parameters for reservation of network resources.

b) QoS monitoring

QoS control in ECTP is based on feedback of control packets from TS-users. The feedback messages from TS-users enable TC-Owner to keep track of the number of active TS-users and also to monitor the connection status for forward multicast data channel and backward unicast data channel. QoS monitoring is designed to allow TC-Owner to diagnose the connection status in terms of QoS parameter values, and thus to take the necessary actions for maintaining the connection status at a desired QoS level. The monitored connection status will be reported to the application at TC-Owner side. For example, the feedback information could provide statistics, which are useful for billing purposes.

c) QoS maintenance

Based on the feedback information from TS-users, TC-Owner takes one or more actions to maintain the connection status at a desired QoS level. These QoS maintenance actions include adjustment of the data transmission rate, connection pause and resume, troublemaker ejection and connection termination operations. Based on monitored parameter status, these QoS monitoring and maintenance functions provide rate-based congestion control.

This Recommendation | International Standard is an integral part of ECTP-3 (ITU-T Rec. X.607 | ISO/IEC 14476-3). All of the protocol components, including packet formats and protocol procedures specified in ITU-T Recommendation X.607 | ISO/IEC International Standard 14476-3, are also valid in this Recommendation | International Standard.

2 Normative references

The following ITU-T Recommendations and International Standards contain provisions that, through references in the text, constitute provisions of this Recommendation | International Standard. At the time of publication, the editions indicated were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations | International Standards listed below. ISO and IEC members maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU-T maintains a list of currently valid ITU-T documents.

a) ITU-T Recommandation X.601 (2000), Information technology – Multi-Peer Communications Framework

b) ITU-T Recommandation X.602 (2005) | ISO/IEC 16513:2005, Information Technology – Group Management Protocol (lGMP)

c) ITU-T Recommandation X.605 (1998) | ISO/IEC 13252:1999, Information technology – Enhanced Communications Transport Service Definition

d) ITU-T Recommandation X.606 (2001) | ISO/IEC 14476-1:2002, Information technology – Enhanced Communications Transport Protocol: Specification of Simplex Multicast Transport (ECTP-1)

e) ITU-T Recommendation X.606.1 (2002) | ISO/IEC 14476-2:2003, Information technology – Enhanced communications Transport Protocol : Specification of QoS Management for Simplex Multicast Transport (ECTP-2)

f) ITU-T draft Recommendation X.607 (2007) | ISO/IEC 14476-3:2007, Information technology – Enhanced Communications Transport Protocol: Specification of Duplex Multicast Transport (ECTP-3)

3 Definitions

3.1 Terms defined in ITU-T Rec. X.605 | ISO/IEC 13252

This Recommendation | International Standard is based on the concepts developed in Enhanced Communications Transport Service (ITU-T Rec. X.605 | ISO/IEC 13252).

a) QoS parameters;

b) QoS negotiation;

c) QoS arbitration.

3.2 Terms defined in ITU-T Rec. X.606 | ISO/IEC 14476-1

This Recommendation | International Standard is described based on the concepts and terms developed in the specification of simplex multicast transport on ECTP (ITU-T Rec. X.606 | ISO/IEC 14476-1).

a) application;

b) packet;

c) sender;

d) receiver;

e) tree;

f) parent;

g) child.

3.3 Terms defined in ITU-T Rec. X.606.1 | ISO/IEC 14476-2

This Recommendation | International Standard is described based on the concepts and terms developed in the specification of simplex multicast transport on ECTP (ITU-T Rec. X.606.1 | ISO/IEC 14476-2).

a) QoS monitoring

b) QoS maintenance.

3.4 Terms defined in ITU-T Rec. X.607 | ISO/IEC 14476-3

This Recommendation | International Standard is described based on the concepts and terms developed in the specification of duplex multicast transport on ECTP-3 (ITU-T draft Rec. X.607 | ISO/IEC 14476-3).

a) SU (Sending User)

Some of the ECTP-3 TS-users can send unicast data to the TC-Owner. A sending user (SU) is a TS-user who gets a token from TC-Owner. Only the SU is allowed to send unicast data to TC-Owner. In other words, before sending unicast data, each user must request a token to TC-Owner;

b) Token

It represents the rights for a TS-user to transmit data. The TS-user who has a token is called a Sending User (SU). The tokens are managed by TC-Owner;

c) Forward Data Channel

It represents the multicast data channel from TC-Owner to the group members. TC-Owner sends multicast data to all the other group members over IP multicast address.

d) Backward Data Channel

It represents the unicast data channel, in which the data packet flows from an SU to TC-Owner. An SU can send unicast data to TC-Owner over IP unicast address.

4 Abbreviations

This Recommendation | International Standard uses the following abbreviations.

4.1 Packet types

CR	Connection Creation Request
CC	Connection Creation Confirm
TJ	Tree Join Request
TC	Tree Join Confirm
DT	Data
ND	Null Data
RD	Retransmission Data
ACK	Acknowledgment
HB	Heartbeat
HBACK	Heartbeat Acknowledgment
JR	Late Join Request
JC	Late Join Confirm
LR	User Leave Request
CT	Connection Termination Request
TGR	Token Get Request
TGC	Token Get Confirm
TRR	Token Return Request
TRC	Token Return Confirm

4.2 Miscellaneous

ACK	Acknowledgment
API	Application Programming Interfaces
CHQ	Controlled Highest Quality
Diffserv	Differentiated Services
ECTP-1	ECTP part 1 (ITU-T Rec. X.606 | ISO/IEC 14476-1)
ECTP-2	ECTP part 2 (ITU-T Rec. X.606.1 | ISO/IEC 14476-2)
ECTP-3	ECTP part 3 (ITU-T Rec. X.607 | ISO/IEC 14476-3)
ECTP-4	ECTP part 4 (ITU-T Rec. X.607.1 | ISO/IEC 14476-4)
ECTP-5	ECTP part 5 (ITU-T Rec. X.608 | ISO/IEC 14476-5)
ECTP-6	ECTP part 6 (ITU-T Rec. X.608.1 | ISO/IEC 14476-6)
ECTS	Enhanced Communications Transport Services (ITU-T Rec. X.605 | ISO/IEC 13252)

IP	Internet Protocol
LQA	Lowest Quality Allowed
MSS	Maximum Segment Size
OT	Operating Target
QoS	Quality of Service
RSVP	Resource Reservation Protocol

5 Overview

This Recommendation | International Standard provides a specification of QoS management for duplex multicast transport connections. This specification describes the following QoS management operations:

1) QoS negotiation, including reservation of network resources;
2) QoS monitoring;
3) QoS maintenance.

In the connection creation phase, TC-Owner informs TS-users whether QoS management is enabled. If QoS management is enabled, TC-Owner must also specify whether or not QoS negotiation will be performed in the connection. QoS monitoring and maintenance operations are performed, only if QoS management is enabled.

Figure 2 illustrates these QoS management operations for the duplex multicast connection. In the figure, the protocol operations marked as dotted lines are specified in ITU-T Rec. X.607 | ISO/IEC 14476-3.

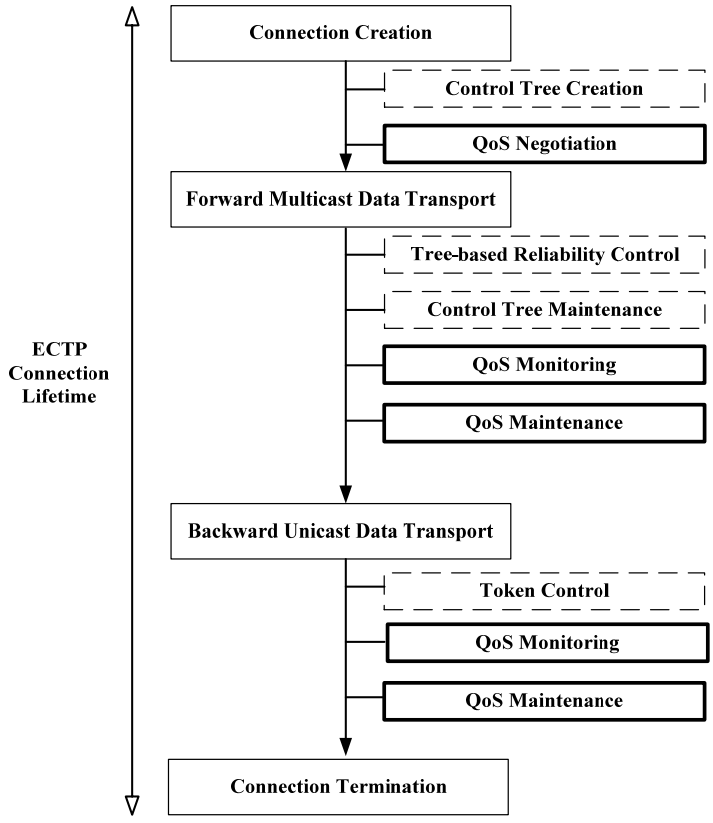


Figure 2 – QoS management in the duplex connection

In this figure, it is noted that the basic control operations of the duplex multicast connection are described in the ECTP-3 specification, such as the tree-based reliability control, control tree maintenance for forward multicast channel, and the token control for backward channels in the duplex multicast connection. It is also noted that the QoS monitoring and maintenance operations for forward multicast channel are specified in the ECTP-2 specification. In this specification, the QoS negotiation for the duplex multicast connection and the QoS monitoring and maintenance operations for 'backward unicast channel' will be introduced.

From the requirements of the applications, TC-Owner will determine the target values for each QoS parameter. The procedures of mapping the application's requirements to those target parameter values is outside the scope of this specification. Application programs could be used to carry out such mappings

QoS negotiation is performed in the connection creation phase. TC-Owner proposes the desired target values for each QoS parameter for forward multicast data channel and backward unicast data channel to all TS-users by multicast via CR message. For throughput parameter, three target values are specified: CHQ (controlled highest quality), OT (operating target) and LQA (lowest quality allowed). For the other parameters such as transit delay, transit delay jitter, and data loss rate, only two target values are specified: OT and LQA.

If QoS negotiation is enabled, each TS-user can propose modifications to the TC-Owner's proposed parameter values. These modified values will be determined by considering the system capacity at TS-user side and network environments. The following restrictions are imposed for modification of parameter's values by TS-users:

1) OT values must not be modified by TS-users;

2) The values modified by TS-users must be within LQA and CHQ values proposed by TC-Owner.

The parameter values modified by TS-users are delivered to TC-Owner via CC messages. TC-Owner arbitrates different parameter values for various TS-users by taking a default range of values.

Figure 3 shows an abstract sketch of QoS negotiation that can occur in ECTP-4. From the application's requirements, a set of target QoS parameter values for forward multicast data channel and backward unicast data channel will be configured at TC-Owner. TC-Owner informs TS-users about the target values for forward multicast data channel and backward unicast data channel (step 1). Based on those target values, each TS-user begins to make resource reservations with help of RSVP or Diffserv (step 2). If QoS negotiation is enabled in the connection, each TS-user may propose modified values for QoS parameters for forward multicast data channel and backward unicast data channel (step 3). From these modified parameter values, TC-Owner determines the arbitrated values (step 4). These arbitrated values are delivered to TS-users via subsequent HB or JC packets, and will be used for QoS monitoring and maintenance.

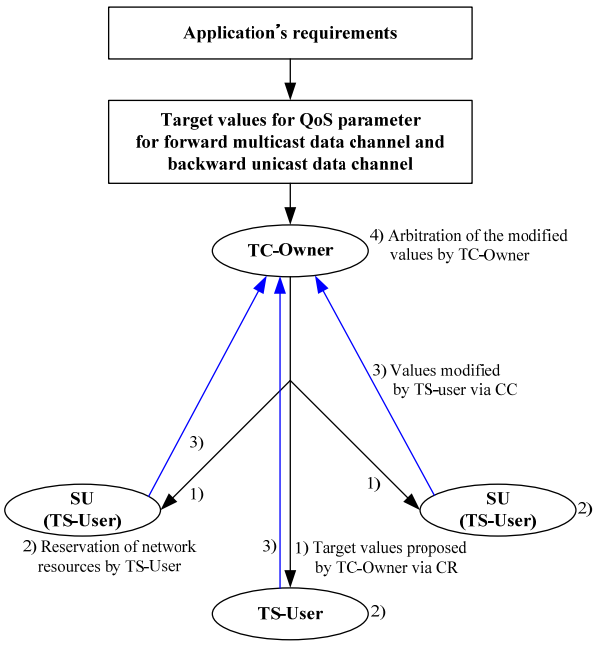


Figure 3 – QoS negotiation in the ECTP duplex connection

After an ECTP connection is created, and consequently if QoS management is enabled, the QoS monitoring and maintenance operations are performed for forward multicast data channel and backward unicast data channel. For QoS monitoring, each TS-user is required to measure the parameter values experienced for forward multicast data channel and TC-Owner is required to measure the parameter values experienced for backward unicast data channel. Based on the measured values and the negotiated values, a TS-user determines a parameter status value for each parameter as an integer: normal (0), reasonable (1), possibly abnormal (2), or abnormal (3). These status values will be delivered to TC-Owner via ACK packets. TC-Owner aggregates the parameter status values reported from TS-users. If a control tree is employed, each parent Local Owner (LO) node aggregates the measured values reported from its children, and forwards the aggregated value(s) to its own parent using ACK packets. In backward unicast data channel, these status values will be delivered to sending TS-user from TC-Owner via HBACK used for retransmission request.

TC-Owner takes QoS maintenance actions necessary to maintain the connection status at a desired QoS level, based on the monitored status values. Specific rules are pre-configured to trigger QoS maintenance actions such as data transmission rate adjustment, connection pause, and resume, troublemaker ejection and connection termination. Those actions will be taken by observing how many TS-users are in the abnormal or possibly abnormal state. In backward unicast data channel, each sending TS-user will takes the associated QoS maintenance actions based on the status values contained in the HBACK packets delivered to the sending TS-user from TC-Owner.

6 Components for QoS management

This section describes the ECTP-3 protocol components required for QoS management operations. All of the components are extended from those already defined in ITU-T Rec. 607 | ISO/IEC 14476-3.

6.1 Base Header

Figure 4 shows the base header specified in ITU-T Rec. 607 | ISO/IEC 14476-3 (in case of ECTP-3 over IP).

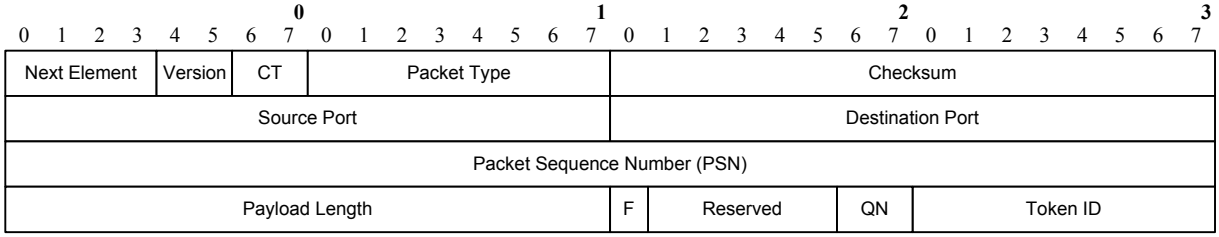
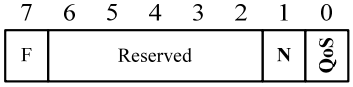


Figure 4 – Base Header in ECTP-3

For QoS management, TC-Owner additionally specifies the following two fields in the '*QoS'* and *'N*' bits:



1) *QoS* - is a flag bit to indicate whether QoS management is enabled (1) or not (0) in the connection. If this bit is set to '1', all the procedures for QoS management are invoked. The default value is '0';

2) *N (Negotiation)* - is a flag bit to indicate whether QoS negotiation is enabled (1) or not (0) in the connection. If this bit is set to '1', each TS-user is allowed to propose its own parameter values for forward multicast data channel and backward unicast data channel. The default value is '0';

The QoS bit must be set to "1" (QoS enabled) before the N bit is valid. There are three possible cases.

a) QoS bit set to "1" and N bit set to "0" indicates that QoS is to be used in the connection, and QoS values will be imposed by TC-Owner. TS-users cannot negotiate it.

b) Both bits set to "1" indicates that QoS is to be used in the connection, and QoS parameter values may be negotiated between TS-users and TC-Owner.

c) QoS bit set to "0" indicates that QoS is not to be used in the connection. The N bit is not used in this case.

6.2 QoS parameters

As specified in the ECTP-2, the following four QoS parameters are defined for duplex connection:

1) throughput (bytes per second);
2) transit delay (millisecond);
3) transit delay jitter (millisecond);
4) data loss rate (percent).

Throughput parameter represents an amount of application data output over a specific time period. Target throughput means a throughput value required for desirable display of application data. In forward multicast data transport, applications generate multicast data and TC-Owner will transmit them, based on the target throughput value(s). If TS-user gets a token from TC-Owner to send unicast data, the applications at a sending TS-user side generates unicast data for backward unicast data transport and the sending TS-user will transmit them to TC-Owner, based on the target throughput value(s) from TC-Owner. Actual data reception rate at TS-user's side will depend on data transmission rate, network conditions and end system capacity, etc.

For throughput, TC-Owner shall configure the following target values:

1) CHQ throughput;
2) OT throughput;
3) LQA throughput.

Among them, the following inequalities must be enforced: LQA throughput $\leq$ OT throughput $\leq$ CHQ throughput.

Transit delay represents end-to-end transmission time from a sender to a receiver. For desirable display of forward multicast data and backward unicast data, TC-Owner may configure the following target values:

1) OT transit delay;
2) LQA transit delay.

Between them, the following inequalities must be enforced: OT transit delay $\leq$ LQA transit delay.

Transit delay jitter represents variations of transit delay values. For desirable display of forward multicast data and backward unicast data, TC-Owner may configure the following target values:

1) OT transit delay jitter;
2) LQA transit delay jitter.

Between them, the following inequalities must be enforced: OT transit delay jitter $\leq$ LQA transit delay jitter.

Data loss rate is defined as a ratio of the amount of lost data over the amount of totally transmitted data. For desirable display of forward multicast data and backward unicast data, TC-Owner may configure the following target values:

1) OT loss rate
2) LQA loss rate

Between them, the following inequalities must be enforced: OT loss rate $\leq$ LQA loss rate.

6.3 QoS extension element

QoS extension is a newly defined element for QoS management in this specification. All the extension elements used in ECTP-3 are listed below.

Table 1 - Extension Elements of ECTP-4

Extension Element	Encoding Value in Next Element (4 bits)	Length of Extension Element (bytes)
No Element	0000	0
Connection	0001	4
Acknowledgment	0010	Varied
Membership	0011	4
Timestamp	0100	12
QoS	0101	28
Address	0110	8 or 20

The QoS extension element specifies the Maximum Segment Size (MSS) and the target values for ECTP-4 QoS parameters, which is described in the ECTP-2. For a more detailed structure of the QoS extension element, refer to the ECTP-2 specification.

The QoS element is used for the TC-Owner to inform the TS-users about the target values for QoS parameters for forward multicast data transport and backward unicast data transport by sending a CR packet in the connection creation phase. In QoS negotiation, the QoS element is also used when a TS-users proposes its own modified values to TC-Owner. The negotiated QoS values will be announced to late-joiners via the JC packet and to existing TS-users via HB packets.

These QoS values are also referred to by TS-users in the QoS monitoring and maintenance operations.

6.4 Acknowledgement element

For QoS monitoring, each TS-user is required to measure the parameter values that have been experienced. A measured parameter value is mapped to a parameter status value. A status value is an integer such as 0, 1, 2, or 3. A larger status value indicates a worse status for the connection.

For forward multicast data transport the status values are delivered to TC-Owner via ACK packets, whereas for backward unicast data transport the status values are delivered to TC-Owner via HBACK. The acknowledgement element of the ACK packet and HBACK packet contain the status values for QoS parameters used in the connection.

The acknowledgement element for duplex connection specified in ITU-T Rec. X.607 | ISO/IEC 14476-3 is shown below. In this figure, the '*parameter status*' byte is defined in this specification for QoS management.

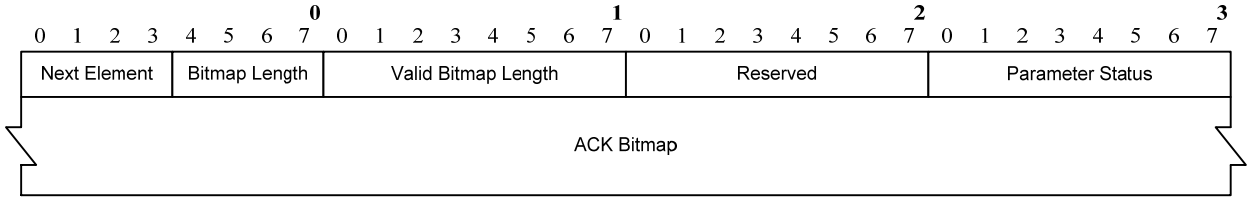
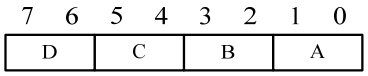


Figure 5 – Acknowledgment extension element

The '*parameter status*' byte has the following structure:



a) A – represents two bits to indicate the status value for the measured throughput;

b) B – represents two bits to indicate the status value for the measured transit delay;

c) C – represents two bits to indicate the status value for the measured transit delay jitter;

d) D – represents two bits to indicate the status value for the measured packet loss rate.

A status value consisting of two bits has one of the following values:

a) 00 – indicates '0' as a status value;

b) 01 – indicates '1' as a status value;

c) 10 – indicates '2' as a status value;

d) 11 – indicates '3' as a status value.

The detailed mapping schemes from a measured parameter value to a status value are described in section (8.1.2).

6.5 Packets used for QoS management

Table 2 lists the ECTP-4 packets used for QoS management.

Table 2 – ECTP-4 packets used for QoS management

Packet type	Extension Element					
	Connection	Membership	Acknowledgement	Timestamp	Address	QoS
CR	O					O
CC						O
HB		O		O		O
HBACK		O	O	O		
ACK		O	O			
JC	O				O	O

The CR packet contains a QoS element. This is used by TC-Owner to propose (or impose) the target values of the QoS parameters that are used in the connection. These values can be referenced by resource reservation mechanisms and protocols, such as RSVP, if they are enabled in the network. If QoS negotiation is enabled, each TS-user responds to TC-Owner with its own proposed values for QoS parameters, via a CR packet. TC-Owner will arbitrate the returned proposals, and the arbitrated values for the QoS parameters will be delivered to TS-users via HB packets. For a late joiner, the target QoS parameter values currently being used in the connection (whether imposed or negotiated originally) are notified via a JC packet.

The target or negotiated values will be referred to in QoS monitoring and maintenance operations. It is noted that the ACK packets are used to convey the status values for QoS parameters experienced at TS-user side in the forward multicast channel, whereas the HBACK packets are used in the backward unicast channel.

7 QoS negotiation for duplex multicast connection

TC-Owner transmits a CR packet to all TS-users to start the connection creation phase. The CR packet contains the proposed (or imposed) target values for each QoS parameter such as CHQ, OT, and LQA for forward multicast data channel and backward unicast data channel. Each TS-user can refer to these target values for resource reservation, whereever applicable. If QoS negotiation is enabled in the connection, the negotiation procedures are activated. The imposed or negotiated target values are subsequently used in QoS monitoring and maintenance.

If QoS negotiation is enabled in the connection, each TS-user can propose a new modified value for forward multicast data channel and backward unicast data channel (by a capability of sending TS-user when it is necessary) in response to a target parameter value proposed by TC-Owner. To propose a new value, a TS-user is required to be able to identify the system or network resources to be used. For example, a modified throughput value may be assessed from line rates of transmission links accessible at the TS-user site (e.g., DSL, cable modem, and wireless networks, etc). The modified value may also be determined by considering the end user's requirement for receiving multicast data and sending unicast data at a TS-user site. It is possible for an end host to use a software program to determine a modified parameter value for negotiation, based on network and system resources as well as end user's requirements. However, in real world scenarios, it is not easy to precisely identify the resource capacity of the networks involved with a receiver. Accordingly, QoS negotiation will be done based on the end user's requirements at the application level or on the system capacity of the end host in near future.

In this specification, TC-Owner is required to specify via the QoS extension element whether each QoS parameter is subject to negotiation. For the parameters that are negotiable, a TS-user can propose modified values. If a TS-user does not wish to modify a QoS parameter, it will just return the same QoS element received from TC-Owner.

7.1 Negotiation procedures

If QoS negotiation is enabled in the connection, each TS-user responds to TC-Owner with a CC packet containing the modified target values for the respective QoS parameters.

This section describes the QoS negotiation procedures for the throughput parameter, which has three target values: LQA, OT, and CHQ. The negotiation procedures for the other parameters such as delay, jitter and loss rate are all the same except that these parameters have no CHQ values.

During QoS negotiation, TS-users must not modify the OT value for each parameter. The detailed procedures for QoS negotiation are described below and illustrated in Figure 6.

1) TC-Owner proposes target parameter values for forward multicast data channel and backward unicast data channel

   From application requirements, TC-Owner determines the target parameter values for forward multicast data and backward unicast data: LQAo, OTo, CHQo, where LQAo < OTo < CHQo, and then transmits a CR packet with two QoS extension elements for forward multicast data channel and backward unicast data channel to all TS-users.

2) TS-users modify the parameter values for forward multicast data and backward unicast data

   In response to the target values proposed by TC-Owner, each TS-user *i* can propose the modified values for forward multicast data and backward unicast data: LQA_i and CHQ_i. OTo value must not be changed. Thus, the following inequalities are enforced: $LQAo < LQA_i < OTo < CHQ_i < CHQo$ for each TS-user *i*. Each TS-user delivers the modified values to TC-Owner via a CC packet with two QoS extension element for forward multicast data and backward unicast data.

3) TC-Owner arbitrates the modified parameter values for forward multicast data and backward unicast data

   TC-Owner arbitrates the modified parameter values proposed by TS-users as follows

   $$CHQmin = \min CHQ_i, \text{ for each TS-user } i;$$

   $$LQAmax = \max LQA_i, \text{ for each TS-user } i.$$

   LQAmax and CHQmin are the negotiated parameter values that have resulted from QoS negotiation.

4) TC-Owner announces the negotiated parameter values.

   TC-Owner announces LQAmax, CHQmin, and OT values to TS-users via HB and JC packets.

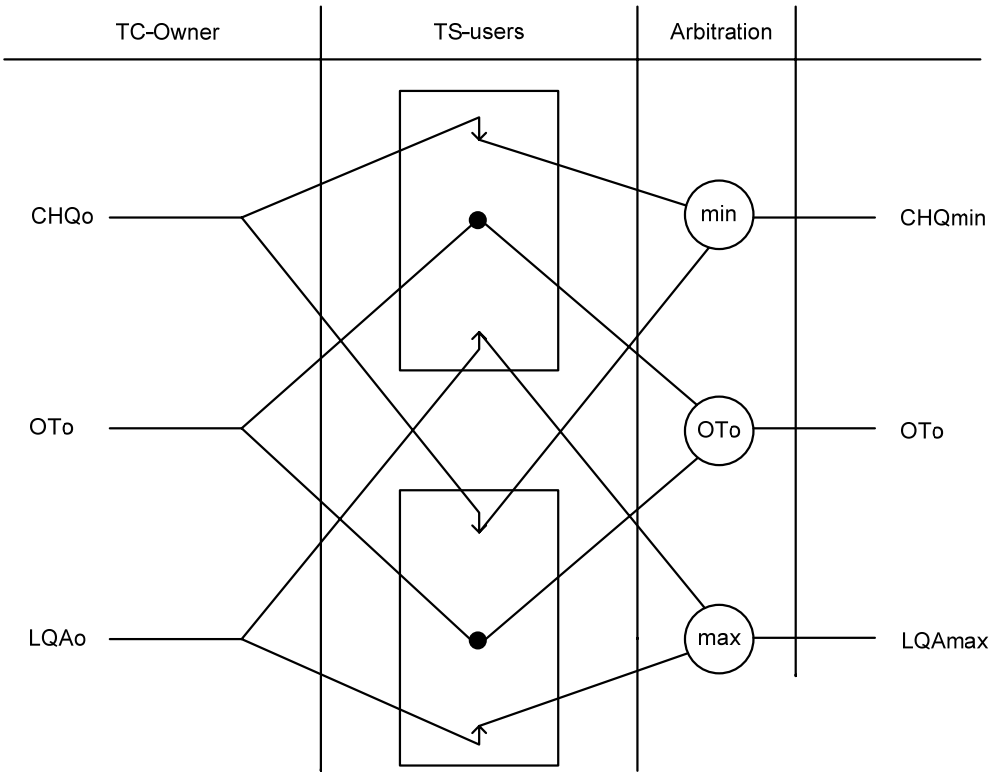


Figure 6 – QoS Negotiation Procedure

For delay, jitter, and loss rate parameters, an LQAmin value will be obtained instead of LQAmax, since CHQ values are not used and OT value < LQA value for those parameters. That is,

$$LQAmin = \min LQA_i, \text{ for each TS-user } i.$$

QoS negotiation is not performed for late-joining TS-users. TC-Owner just notifies the negotiated parameter values to the late-joining TS-user via JC packet.

It is noted that the negotiated QoS parameter values will be referred to the QoS monitoring and maintenance operations for forward and backward data channels and are not modified in the data transport phase.

7.2 QoS negotiation in the tree hierarchy

If a control tree with more than two levels is employed for the forward multicast channel, each parent Local Owner (LO) must perform the QoS arbitration procedures for the modified values proposed by its children, which is described in the ECTP-2 specification.

The MSS negotiation operations are also performed in the same way that is specified in the ECTP-2 specification.

7.3 Resource Reservation

ECTP itself cannot guarantee the QoS levels required by applications. However, the target values of QoS parameters can be used in the reservation of network resources such as Integrated Services with RSVP and Differentiated Services (Diffserv). The examples of the detailed interworking scenarios for resource reservation are given in the ECTP-2 specification.

8 QoS monitoring and maintenance for the forward channel

This specification of ECTP-4 describes the QoS monitoring and maintenance functions for the duplex multicast connection defined in the ECTP-3. For the forward multicast channel of the duplex connection, the corresponding QoS monitoring and maintenance operations are performed in the same way as specified in the ECTP-2.

8.1 QoS monitoring for the forward multicast channel

The QoS monitoring function provides TC-Owner with information about how well the forward multicast channel of the duplex connection is operating. To do this, each TS-user is required to measure the parameter values experienced and report these values back to TC-Owner.

For the QoS parameters used in the connection, each TS-user measures the parameter values that have been experienced. The measured value is mapped to a parameter status value for each parameter. A parameter status is an integer having a value of 0, 1, 2, or 3. This status value is recorded in the acknowledgement element and conveyed to TC-Owner via a subsequent ACK packet. TC-Owner aggregates the parameter status values from all TS-users.

The purpose of QoS monitoring is to provide TC-Owner with information on QoS status for the connection. Based on the monitored status information, TC-Owner can also take any QoS maintenance necessary actions.

8.1.1 Generation of ACK

Each TS-user reports the parameter status values to its parent by generating ACK packets. In ECTP-5, ACK Generation Time (*AGT*) is set to equal ACK Generation Number (*AGN*). More specifically, *AGT* is set to be '*AGN* x 1 second, i.e., *AGN* seconds.' Accordingly, each TS-user will generate periodic ACK packets for every *AGT* second. Setting of *AGN* is an implementation issue.

To generate ACK packet, each TS-user must keep a timer, QoS monitoring time (*QMT*), in seconds. The *QMT* timer starts as soon as TS-user completes the connection setup, i.e. after reception of CC or JC packet from TC-Owner. *QMT* timer increases monotonically as the connection progresses. That is, it will not be refreshed during the connection.

Each TS-user transmits an ACK packet to its parent if

$$QMT \% AGN = Child\ ID \% AGN.$$

This scheme is employed to minimize ACK implosions at the parent side as much as possible. By this mechanism, each TS-user will continue to generate ACK packets every *AGN* second, after the *QMT* timer begins. For example, if *AGN* is set to 8, then a receiver with Child ID of either 3 or 11 will generate ACK packets at the *QMT* times of 3, 11, 19, 27 seconds, etc. It is noted in the example that the first ACK will be generated for data packets transmitted only during 3 seconds not 8 seconds. However, the other succeeding ACK packets are generated for the time interval of *AGN* seconds. In this manner, each TS-user will generate ACK packets every *AGN* second, except for the first ACK packet.

Each ACK packet conveys the measured parameter status value as described in the ECTP-2 specification.

8.1.2 Measurement of QoS parameter values

For forward multicast data transmission, each TS-user measures the experienced values for each QoS parameter. All the parameter values are measured, recorded and calculated, until a new ACK packet is generated according to the ACK generation rule described above. When it is time to send an ACK, a TS-user calculates the parameter status value for the data packets received and collected until then. After transmitting an ACK, the collected data is cleared and then new data will be gathered and recorded for generating a new ACK.

Throughput is measured as the data reception rate in units of bytes per second. The data reception rate is calculated by

$$Amount\ of\ the\ received\ data\ packets\ in\ bytes\ over\ AGN\ seconds.$$

Again, the first ACK packet may be generated before *AGN* seconds have elapsed. To measure the throughput value, a receiver needs to keep information about how much data packets (bytes) have been received for the specific time.

Each time a new throughput value is obtained, the value is mapped to the *parameter status value*, an integer value of 0, 1, 2, or 3, according to the mapping rule that will be described in the ECTP-2 specification.

Data loss rate represents the packet loss rate, and it is expressed in percent. The packet loss rate is calculated by

Number of lost packets over Number of the data packets received during AGN seconds.

Again, the first ACK packet may be generated before *AGN* seconds have elapsed. To measure the throughput value, TS-user needs to keep information about how many data packets have been lost. When TS-user generates an ACK packet, the currently measured loss rate value is mapped to the *parameter status value*.

To measure an end-to-end transit delay, TC-Owner is required to transmit data packets with a timestamp element. Another requirement is the synchronization of time clocks between TC-Owner and TS-user. Without adequate resolution of these requirements, it is hard to get exact information about transit delay and jitter. In this section, it is assumed that each TS-user can measure an end-to-end transit delay of a data packet from TC-Owner.

Transit delay is measured for each data packet received. These transit delay values are averaged over the data packets received during *AGN* seconds. Transit delay jitter is measured as the difference between the maximum and minimum transit delay values of those received data packets.

During the *AGN* seconds, every time a new data packet arrives, the transit delay is calculated, and the averaged delay and jitter values are updated. Just before TS-user generates an ACK packet, the currently measured value will be mapped to the *parameter status value*.

8.1.3 Mapping to a parameter status value

The measured parameter value is mapped to a parameter status value for each QoS parameter. The subsequent ACK packet will contain the status value. Note again that measurement of a QoS parameter is activated only if the use of the parameter in the connection is indicated.

The following figure illustrates the mapping from the measured value to a status value.

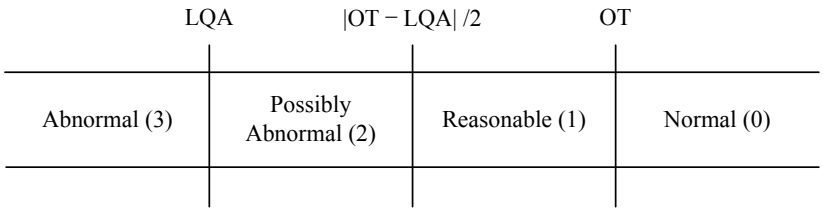


Figure 7 – Mapping of the measured value to a status value

As shown in the figure, the mapping from the measured parameter value to a status value is done based on OT and LQA parameter values. ECTP also uses a *threshold* value to classify the status into normal (0), reasonable (1), possibly abnormal (2), and abnormal (3). The *threshold* value is set to a medium value between OT and LQA parameter values (i.e., |LQA – OT| / 2), as shown in the figure.

An initial *parameter status value* is set to '0'. Once the measured value is obtained, the mapping to a *parameter status value* is done as follows:

IF "*measured parameter value* > OT," then status = 0,

ELSE IF "*threshold* < *measured parameter value* ≤ OT," then status = 1,

ELSE IF "LQA < *measured parameter value* ≤ threshold," then status = 2,

ELSE IF "*measured parameter value* ≤ LQA," then status = 3.

In the above mapping rules, the inequalities hold true only for throughput parameter. For the other parameters such as delay, jitter, and loss rate, those inequalities must be reversed, because OT values ≤ LQA values.

8.1.4 Reporting toward TC-Owner

Each TS-user reports the obtained *parameter status values* to its parent via ACK packets. The ACK packets are generated based on *child ID* and *AGN* seconds. In this fashion, all the information about *parameter status values* will be delivered toward TC-Owner along the tree hierarchy.

In the tree hierarchy, each parent Local Owner (LO) aggregates the ACK packets from its children. This aggregation will proceed just before the parent generates its own ACK. The Local Owner (LO) also generates its own ACK packet every *AGN* second, as done by a TS-user. The parent simply takes an average value over the parameter status values reported from its children together with its own measured value, just before it generates ACK packets.

The averaged value is calculated for each QoS parameter by

Summation of parameter status values from the responding children over Active Descendant Number (AND).

In the multi-level tree structure, the number of descendants is represented by *Active Descendant Number (ADN)* recorded in the membership extension element.

A parent Local Owner (LO) rounds this average value to 0, 1, 2, or 3 for each QoS parameter, and composes its ACK packet.

Aggregation of parameter status values by TC-Owner is the same as that by Local Owner (LO). TC-Owner also performs aggregation of ACK packets reported from its children every *AGN* seconds.

After aggregation of ACK packets, TC-Owner simply takes an average value weighted by *ADN* of each child. That is,

Aggregated status value = the weighted sum of reported status values over ADN of the connection

TC-Owner obtains an aggregated status value for each QoS parameter. More specifically, TC-Owner will have the following aggregated status values (if each of the parameters is used in the connection):

a) Aggregated status for throughput, denoted by *Tvalue*,

b) Aggregated status for transit delay, denoted by *Dvalue*,

c) Aggregated status for transit delay jitter, denoted by *Jvalue*,

d) Aggregated status for data loss rate, denoted by *Lvalue*.

Each of the aggregate values is also ranged between 0 and 3.

TC-Owner may forward the monitored status information to the application. The monitored information is beneficial for sending application to diagnose how well the connection is being operated in terms of QoS, which may further be useful for designing a billing/charging model.

The monitored information is also used in the QoS maintenance. Among the monitored values, *Lvalue* is used for adjustment of transmission data rate. A weighted sum value for all the status values, *Tvalue*, *Dvalue*, *Jvalue*, and *Lvalue*, can be used to trigger connection pause, troublemaker ejection and termination.

8.2 QoS maintenance for the forward multicast channel

QoS maintenance is performed to maintain the quality of a connection at a desired level and to prevent the connection quality from being degraded below the negotiated QoS level.

Based on the monitored parameter status values, TC-Owner will take the following QoS maintenance actions:

1) Adjustment of data transmission rate,

2) Connection pause and resume,

3) Troublemaker ejection,

4) Connection termination.

Data rate adjustment is related to the rate-based flow and congestion control. Connection pause/resume and termination are the actions which can be taken to manage the connection. These events will be announced to all TS-users via ND and CT packets transmitted by TC-Owner.

To trigger these QoS maintenance actions, TC-Owner needs to configure the following threshold values:

1) *threshold_rate_increase and threshold_rate_decrease* for adjustment of data transmission rate,

2) *threshold_connection_pause*.

All the threshold values are real numbers ranged between 0 and 3.

8.2.1 Adjustment of data transmission rate

ECTP uses a fixed-sized window-based flow control. TC-Owner can maximally transmit the window size data packets at the rate of *Data Transmission Rate (DTR)*. ECTP performs congestion control by dynamically adjusting *DTR*, based on the loss rate status values *Lvalue*.

Adjustment of data transmission rate is based on *threshold_rate_increase* and *threshold_rate_decrease*, which are preconfigured by TC-Owner from application requirements. These values are ranged as follows:

$$0 \leq \textit{threshold\_rate\_increase} \leq \textit{threshold\_rate\_decrease} \leq 3.$$

The default values are *threshold_rate_increase* = 1.0 and *threshold_rate_decrease* = 2.0.

In the data transmission phase, TC-Owner starts with *DTR* = LQA throughput, and *DTR* can be adjusted as follows:

$$\text{LQA throughput} \leq \textit{DTR} \leq \text{CHQ throughput.}$$

Every *AGN* second, TC-Owner adjusts *DTR*, based on *threshold_rate_increase*, *threshold_rate_decrease*, and the monitored *Lvalue* as follows:

IF *Lvalue* < *threshold_rate_increase*,

THEN *DTR* = *Min* {CHQ, *DTR* + *Transmission Rate Increase (TRI)*}

ELSF IF *threshold_rate_increase* ≤ *Lvalue* ≤ *threshold_rate_decrease*

THEN *DTR* is not changed

ELSE IF *Lvalue* > *threshold_rate_decrease*

THEN *DTR* = *Max* {LQA, *DTR* – *Transmission Rate Decrease (TRD)*}

Rate adjustment variables such as *TRI* and *TRD* may be set based on CHQ and LQA throughput. For examples,

TRI = (CHQ – LQA) x 1/20

TRD = (CHQ – LQA) x 1/5

8.2.2 Connection pause and resume

Connection pause can be performed by TC-Owner to suspend the multicast data transmissions temporarily so as to prevent the connection quality from being more severely degraded.

Connection pause and resume may be performed, according to the request of application. In this case, the sending application at TC-Owner side will trigger the connection pause, based on monitored parameter status values such as *Tvalue*, *Dvalue*, *Jvalue* and *Lvalue*. If the connection pause is triggered, TC-Owner transmits periodic ND packets with the 'F' bit set to '1' in the base header, as specified in the ECTP-3. TC-Owner must not transmit any new DT packet, while the control packets including HB packets can be sent. Each TS-user may also send control packets such as HBACK.

Connection pause may also be triggered, based on the pre-configured *threshold_connection_pause*. In this case, only if the monitored connection status value is larger than *threshold_connection_pause*, TC-Owner will trigger the connection pause. The suggested *threshold_connection_pause* value is 2.5.

For this purpose, *Connection Status* value is calculated for all the monitored parameter status values as follows.

$$\textit{Connection Status} = \textit{Tweight x Tvalue} + \textit{Dweight x Dvalue} + \textit{Jweight x Jvalue} + \textit{Lweight x Lvalue.}$$

Each of the weight values must also be configured, along with *threshold_connection_pause*, where the following constraints are imposed:

$$0 \leq \textit{Tweight, Dweight, Jweight, Lweight} \leq 1,$$

$$\textit{Tweight} + \textit{Dweight} + \textit{Jweight} + \textit{Lweight} = 1.$$

A weight value is set to '0' if the corresponding QoS parameter is not enabled in the connection.

The connection pause is triggered if

$$Connection\ Status \geq threshold\_connection\_pause.$$

After connection pause was indicated, if the *Connection Pause Time (CPT)* interval has elapsed, then connection resume is triggered and TC-Owner begins to transmit forward multicast data at the transmission rate of LQA. When connection resume is indicated, ND packets will set the 'F' bit of the header to '0'.

8.2.3 Troublemaker ejection

TC-Owner or Local Owner (LO) may invoke a troublemaker ejection to maintain the QoS status at a desired level and also to prevent the connection status from being more severely degraded. A detailed scheme of the troublemaker ejection can be made differently by implementations, based on the parameter status values provided in this specification.

For example, a TS-user may be ejected by its parent, if it has reported a *parameter status value* larger than *threshold_connection_pause* several times more than a pre-configured threshold. The design and implementation of the troublemaker ejection scheme must be done carefully, since the ejection operation may have significant impact on the overall ECTP protocol behaviour.

8.2.4 Connection termination

The default option for the connection termination is to terminate a connection when all the forward multicast data have been transmitted. In QoS management operations, connection termination is also triggered if the connection status is perceived as 'unrecoverable.'

Connection termination may be performed according to the request of the application. If the connection termination is triggered, TC-Owner transmits a CT packet to all the TS-users, and closes the connection.

Connection termination may also be triggered, based on the pre-configured *Connection Termination Time (CTT)*. In this case, connection termination is triggered if

Subsequent connection pause occurs again within *CTT* from connection resume.

The *CTT* timer is activated when connection resume is indicated. Connection termination may not be supported by some applications.

9 QoS monitoring and maintenance for the backward channel

An ECTP duplex connection consists of a forward multicast channel from TC-Owner to TS-users and also one or more backward unicast channels from sending TS-users to the TC-Owner, as specified in the ECTP-3. The QoS monitoring and maintenance operations for each backward channel will be performed between TC-Owner and the corresponding TS-user.

9.1 QoS monitoring for the backward unicast channel

The QoS monitoring function for a backward unicast channel will be performed by the TC-Owner, which is the recipient of the backward unicast channel. To do this, the TC-Owner is required to measure the QoS parameter values experienced and report these values back to the corresponding TS-user.

The measured value is mapped to a parameter status value for each parameter. A parameter status is an integer having a value of 0, 1, 2, or 3. This status value is recorded in the acknowledgement element that is contained in the HBACK packet delivered from TC-Owner to the sending TS-user. It is noted that the backward channel does not require the aggregation of the ACK packets used in the forward channel.

The purpose of QoS monitoring is to provide each sending TS-user with information on QoS status for the backward channel. Based on the monitored status information, the sending TS-user can take any QoS maintenance actions necessary.

9.1.1 Generation of HBACK

For the backward unicast channel, the generation of HBACK packets is described in the ECTP-3 specification. Each HBACK packet conveys the measured parameter status value as described in the ECTP-2 specification.

9.1.2 Measurement of QoS parameter values

In the backward data channel, the sending TS-user and TC-Owner will exchange the HB and HBACK packets over the Heartbeat Generation Time (HGT) interval. For the backward unicast data transmission, the TC-Owner measures the experienced values of QoS parameter for each of the sending TS-users. All the parameter values are measured, recorded and calculated, until a new HBACK packet is generated according to the HBACK generation rule described above.

When it is time to send an HBACK, the TC-Owner calculates the parameter status value for the data packets received and collected until then. After transmitting an HBACK, the collected data is cleared and then new data will be gathered and recorded for generating a new HBACK.

Throughput is measured as the data reception rate in units of bytes per second. The data reception rate is calculated by

Amount of the received data packets in bytes over the HGT interval.

When a new throughput value is obtained, the value is mapped to the *parameter status value*, an integer value of 0, 1, 2, or 3, according to the mapping rule that will be described in the ECTP-2 specification.

Data loss rate represents the packet loss rate, and it is expressed in percentage. The packet loss rate is calculated by

Number of lost packets over Number of the data packets received during HGT seconds.

When the TC-Owner generates a HBACK packet, the currently measured loss rate value is mapped to the *parameter status value*.

To measure an end-to-end transit delay, each sending TS-user is required to transmit data packets with a timestamp element. Another requirement is the synchronization of time clocks between TC-Owner and sending TS-user. Without satisfactory resolution of these requirements, it is hard to get exact information about transit delay and jitter. In this section, it is assumed that each TC-Owner can measure an end-to-end transit delay of a data packet from the sending TS-user.

Transit delay is measured for each data packet received. These transit delay values are averaged over the data packets received during *HGT* seconds. Transit delay jitter is measured as the difference between the maximum and minimum transit delay values of those received data packets.

During the *HGT* seconds, every time a new data packet arrives, the transit delay is calculated, and the averaged delay and jitter values are updated. Just before the TC-Owner generates a HBACK packet, the currently measured value will be mapped to the *parameter status value*.

9.1.3 Mapping to a parameter status value

The rule of mapping the measured QoS parameter value to a parameter status value is the same as described in the forward multicast channel earlier.

9.2 QoS maintenance for the backward unicast channel

In the backward channel of the duplex connection, the QoS maintenance operations will be performed to maintain the quality of a backward unicast data channel at a desired level and to prevent the data channel's quality from being degraded below the negotiated QoS level.

For this purpose, based on the monitored parameter status values, each sending TS-user will take the following QoS maintenance actions:

1) Adjustment of data transmission rate for the backward data channel,
2) Termination of the backward channel.

It is noted that the QoS maintenance operations of the backward channel do not include the troublemaker ejection, connection pause, and connection termination, since these actions will be done only by TC-Owner.

9.2.1 Adjustment of data transmission rate

It is assumed that the sending TS-user transmits the data packets at the rate of *Data Transmission Rate (DTR)*. Then the adjustment of data transmission rate is based on *threshold_rate_increase* and *threshold_rate_decrease*, which are preconfigured by each sending TS-user from application requirements. These values are ranged as follows:

$$0 \leq \textit{threshold\_rate\_increase} \leq \textit{threshold\_rate\_decrease} \leq 3.$$

The default values are *threshold_rate_increase* = 1.0 and *threshold_rate_decrease* = 2.0.

In the data transmission phase, each sending TS-user starts with *DTR* = LQA throughput and *DTR* can be adjusted with the following range:

$$\text{LQA throughput} \leq \textit{DTR} \leq \text{CHQ throughput}.$$

Every HGT second, TC-Owner adjusts *DTR*, based on *threshold_rate_increase*, *threshold_rate_decrease*, and the monitored *Lvalue* (the parameter status value associated the data loss rate) as follows:

IF *Lvalue* < *threshold_rate_increase*,

THEN *DTR* = *Min* {CHQ, *DTR* + *Transmission Rate Increase (TRI)*}

ELSF IF *threshold_rate_increase* ≤ *Lvalue* ≤ *threshold_rate_decrease*

THEN *DTR* is not changed

ELSE IF *Lvalue* > *threshold_rate_decrease*

THEN *DTR* = *Max* {LQA, *DTR* – *Transmission Rate Decrease (TRD)*}

Rate adjustment variables such as *TRI* and *TRD* may be set based on CHQ and LQA throughput. For examples,

TRI = (CHQ – LQA) x 1/20

TRD = (CHQ – LQA) x 1/5

9.2.2 Termination of the backward channel

The default option for termination of a backward unicast channel is for the sending TS-user to stop the backward channel when all the unicast data have been transmitted. In QoS management operations, the termination of the backward channel may also be triggered if the channel status is perceived as ‘unrecoverable.’

Termination of a backward channel may be performed according to the request of the application at the sending TS-user side. If the termination of the backward channel is triggered, the sending TS-user should transmit a TRR (Token Return Request) packet to the TC-Owner, and closes the backward channel.

Appendix A. Implementation Considerations

This Appendix is an informative part of this specification.

The implementation of the ECTP-4 specification shall be done based on the ECTP-3 specification (for the duplex multicast connection) and the ECTP-2 specification (for QoS management for the forward multicast channel).

In particular, the following materials of the ECTP-3 specification will be useful for implementation of this ECTP-4:

1) Appendix A: Timers and parameters for duplex multicast connection;
2) Appendix B: State transition diagrams for duplex multicast connection;
3) Appendix C: Application programming interfaces for duplex multicast connection.

In addition, the following materials of the ECTP-2 specification will also be useful for implementation of this ECTP-4:

1) Appendix A: Interworking between ECTP and RSVP for resource reservation;
2) Appendix B: Application programming interfaces for QoS management of forward multicast channel in the duplex multicast connection.

These informative materials described above will be commonly used in the implementation of ECTP-4.

Along with the reference specification, this specification could be referred to for implementation of the QoS management components of the backward unicast channel in the duplex multicast connection.

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