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ITU-T RECOMMENDATION X.608.1

INFORMATION TECHNOLOGY – ENHANCED COMMUNICATIONS TRANSPORT PROTOCOL:

SPECIFICATION OF QOS MANAGEMENT FOR N-PLEX MULTICAST TRANSPORT

Table of Contents

Summary

This Recommendation describes QoS management functions for the N-plex multicast transport over Internet where IP multicast is supported. QoS management functions such as QoS negotiation, monitoring, and maintenance features are specified. Protocol details such as packet format, parameter values and procedures are described. This protocol can be used for applications that require many-to-many data delivery service with QoS managing facility; the protocol is expected to provide transport service to multimedia conference service over IP multicast, etc.

Introduction

ECTP is designed to support tightly controlled multicast connections in simplex, duplex and N-plex applications. This part of ECTP (part 6: ITU-T Rec. X.608.1) specifies the Quality of Service (QoS) management functions for the N-plex multicast transport protocol (ECTP part 5: ITU-T Rec. X.608 | ISO/IEC 14476-5).

In the N-plex multicast connection, the participants include one TC-Owner and many TS-users. TC-Owner will be designated among the TS-users before the connection begins. TC-Owner is at the heart of multicast group communications. It is responsible for overall connection management by governing the connection creation and termination, multicast data transport, and the late join and leave operations. The multicast data transmissions are allowed by TS-users as well as TC-Owner. Each TS-user is allowed to send multicast data to the group only if it gets a token from the TC-Owner. That is, the multicast data transmissions of TS-users are controlled by TC-Owner.

For the stable QoS management of the N-plex multicast connection, this specification provides the QoS management functions such as QoS negotiation, QoS monitoring, and QoS maintenance.

The target QoS parameters are negotiated between TC-Owner and TS-users before the connection creation. During the connection, the status of the connection is monitored by TS-users and the monitoring result is delivered to Sending TS-users and TC-owner via control packets. According to the QoS monitoring result, Sending TS-users may adjust their data transmission rate and TC-owner may pause or terminate the connection.

This QoS management specification can be used in the multicast applications that want to support various QoS requirements and the corresponding billing/charging models.

ITU-T RECOMMENDATION

INFORMATION TECHNOLOGY – ENHANCED COMMUNICATIONS TRANSPORT PROTOCOL:

SPECIFICATION OF QOS MANAGEMENT FOR N-PLEX MULTICAST TRANSPORT

1. Scope

This Recommendation provides a specification of QoS management for accomplishing desirable quality of service in N-plex multicast transport connection. For this purpose, this specification describes the following QoS management operations in N-plex multicast transport connection:

a) QoS negotiation;

b) QoS monitoring;

c) QoS maintenance

This Recommendation is an integral part of ECTP-5 (ITU-T Rec. X.608 | ISO/IEC 14476-5). All of the protocol components, including packet formats and protocol procedures specified in ITU-T Recommendation X.608, are also valid in this Recommendation.

2. 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.

2.1 Normative References

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

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

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

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

g) ITU-T Recommendation X.608 (2007) | ISO/IEC 14476-5:2007, Information technology – Enhanced communications Transport Protocol : Specification of N-plex Multicast Transport (ECTP-5)

2.2 Informative References

a) ITU-T draft Recommendation X.607.1 (2007), Information technology – Enhanced communications Transport Protocol : Specification of QoS Management for Duplex Multicast Transport (ECTP-4)

3. Definitions

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

This Recommendation 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; and

c) QoS arbitration.

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

This Recommendation 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 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.

3.3 Terms defined in ITU-T Rec. X.608 | ISO/IEC 14476-5

This Recommendation is described based on the concepts and terms developed in the specification of N-plex multicast transport on ECTP-5 (ITU-T Rec. X.608 | ISO/IEC 14476-5).

a) TCN (TC-Owner)

An N-plex multicast connection has a single TCN. The TCN is responsible for connection management including connection creation/termination, late join, connection maintenance, and token management.

For example, in the teleconferencing applications, the TCN may act as the ‘conference server’, which may be used for control of the conferencing without sending multicast data. In the example of ‘multi-users on-line game’ application, the TCN may act as the ‘game-control server’;

b) SU (Sending TS-user)

A TS-user who gets a token from TCN. Only the SU is allowed to send multicast data to the group. In other words, before sending multicast data, each user must request a token to TCN;

c) LO (Local Owner)

For a given subset of participants, LO becomes a root of a locally configured shared tree in the local group. Each LO is also connected to the other LO as the inter-group tree. Each LO will control the tree configuration for the local group. It will also perform the error recovery as parent for the local group;

d) Token

It represents the right for a TS-user to transmit multicast data. The TS-user who has a token is called SU. The tokens are managed by TC-Owner;

e) Multicast Data Channel

TCN or SU can send multicast data to all the other group members over IP multicast address

4. Abbreviations

This Recommendation uses the following abbreviations.

4.1 Packet types

ACK	Acknowledgment
CC	Connection Creation Confirm
CR	Connection Creation Request
CSR	Connection Status Report
CT	Connection Termination Request
DT	Data
JR	Late Join Request
JC	Late Join Confirm
TSR	Token Status Report

4.2 Miscellaneous

ACK	Acknowledgment
ADN	Active Descendent Number
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 draft Rec. X.607.1)
ECTP-5	ECTP part 5 (ITU-T Rec. X.608 | ISO/IEC 14476-5)
ECTP-6	ECTP part 6 (ITU-T draft Rec. X.608.1)
ECTS	Enhanced Communications Transport Services (ITU-T 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. Conventions

<None>

6. Overview

This Recommendation provides a specification of QoS management for N-plex multicast transport connections. This specification describes the following QoS management operations:

a) QoS negotiation, including reservation of network resource;

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 TCN (TC-owner) and TS-users for multicast data channel. TCN proposes the target values of QoS parameters obtained from the application's requirements in order for TS-users to send or receive the multicast data, and then each TS-user can propose modified values based on its system and/or network capacity and its application's requirement. TCN 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-6 is based on feedback of control packets from TS-users. The feedback messages from TS-users enable TCN to keep track of the number of TS-users and also to monitor the connection status for the multicast data channel. QoS monitoring is designed to allow TS-users and TCN 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 TCN side. The information conveyed could provide statistics useful for billing purposes, for example.

c) QoS maintenance

Based on feedback information from TS-users, TCN and SUs (Sending TS-users) take one or more actions so as 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. These QoS monitoring and maintenance functions, based on monitored parameter status, provide rate-based congestion control.

In the connection creation phase, TCN informs TS-users whether QoS management is enabled. If QoS management is enabled, TCN 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 1 illustrates these QoS management operations for the N-plex multicast connection. In the figure, the protocol operations marked as dotted lines are specified in ITU-T Rec. X.608 | ISO/IEC 14476-5.

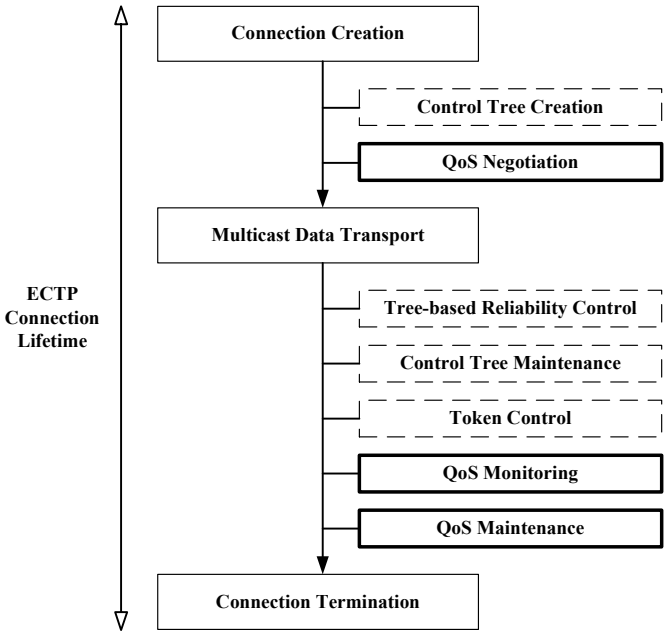


Figure 1 – QoS management in the N-plex connection

In this figure, it is noted that the basic control operations of the N-plex multicast connection are described in the ECTP-5 specification, such as control tree creation, tree-based reliability control, control tree maintenance, and the token control. In this specification, the QoS negotiation, monitoring and maintenance operations for the N-plex multicast connection will be introduced.

From the requirements of the applications, TCN will determine the target values for each QoS parameter. The procedures of mapping the application's requirements to those target parameter values are 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. TCN proposes the desired target values for each QoS parameter for sending multicast data to TS-users and receiving multicast data from SUs by multicast via CR packet. 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 TCN'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 TCN.

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

Figure 2 shows an abstract sketch of QoS negotiation that can occur in ECTP-6. From the application's requirements, a set of target QoS parameter values for multicast data channel will be configured at TCN. TCN informs TS-users about the target values for sending multicast data to TS-users and receiving multicast data from SU (step 1). Based on those target values, each TS-user begins to make resource reservations with help of RSVP [b-IETF RFC2205] [b-IETF RFC2210] or Diffserv [b-IETF RFC2475] (step 2). If QoS negotiation is enabled in the connection, each TS-user may propose modified values for QoS parameters based on its system and/or network capacity and the application's requirements for multicast data channel (step 3). From these modified parameter values, TCN determines the arbitrated values for sending multicast data to other TS-users and receiving multicast data from other TS-users (step 4). These arbitrated values are delivered to TS-users via subsequent TSR or JC packets, and will be used for QoS monitoring and maintenance.

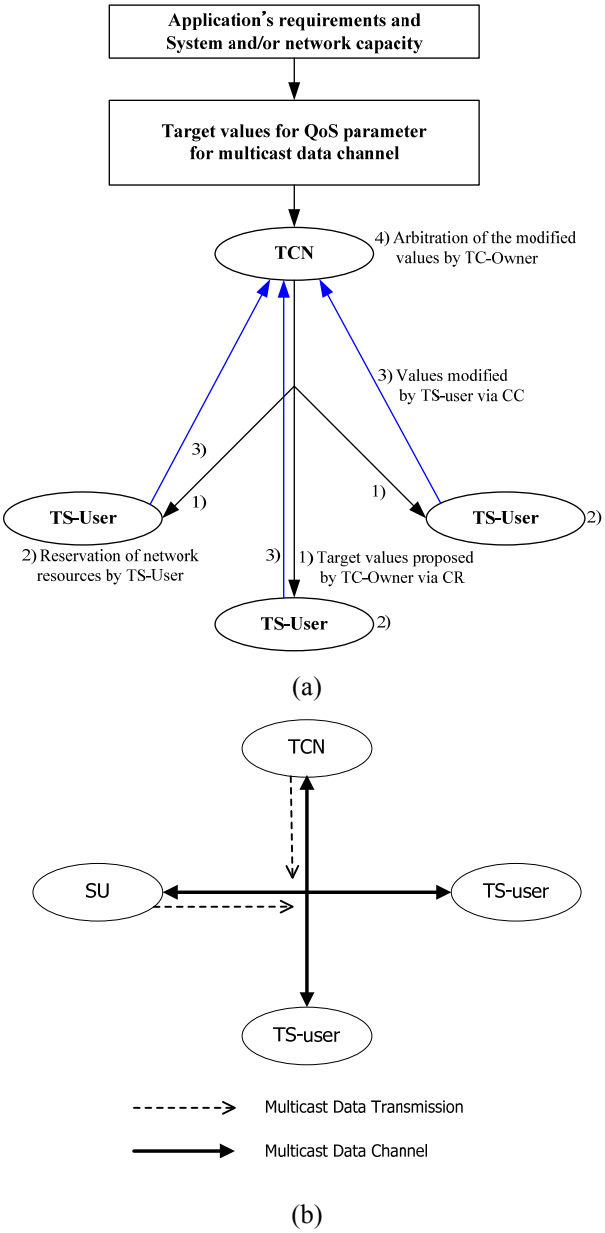


Figure 2 – (a) QoS Negotiation Procedures (b) Multicast Data Transport in ECTP-5

After an ECTP connection is created, and consequently if QoS management is enabled, the QoS monitoring and maintenance operations are performed for multicast data channel. For QoS monitoring, each TS-user is required to measure the QoS parameter values experienced for multicast 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 the parent node via ACK packets along the control tree. Each TS-user aggregates the parameter status values reported from its child nodes and forwards the aggregated value(s) to its own parent using ACK packets. Finally, these status values are delivered to SUs and TCN.

SU and TCN take 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.

7. Components for QoS management

This section describes the ECTP-6 protocol components required for QoS management operations. All of the components are extended from those already defined in ITU-T Rec. 608 | ISO/IEC 14476-5.

7.1 Base Header

Figure 3 shows the base header specified in ITU-T Rec. 608 | ISO/IEC 14476-5 (in case of ECTP-5 over IP). Note that the two 1-bit fields are inserted into the 'Reserved' field of the original base header of ECTP-5.

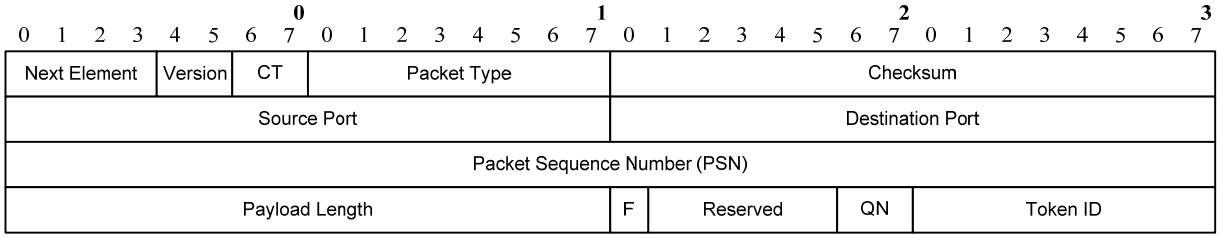
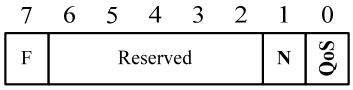


Figure 3 – Base Header in ECTP-5

For QoS management, TCN 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 multicast 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.

1) 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 TCN. TS-users cannot negotiate it.
2) 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 TCN.
3) 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.

7.2 QoS parameters

In this specification,, the following four QoS parameters are defined for N-plex 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 multicast data transport, applications generate multicast data and TCN or SUs will transmit them, based on the target throughput value(s). If a TS-user gets a token from TCN to send multicast data, the applications at SU side generate multicast data for multicast data transport and the SU will transmit them to other TS-user including TCN based on the target throughput value(s) obtained from

TCN. Actual data reception rate at TS-user's side will depend on data transmission rate, network conditions and end system capacity, etc.

For throughput, TCN 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 ≤ OT throughput ≤ CHQ throughput.

Transit delay represents end-to-end transmission time from a sender to a receiver. For desirable display of multicast data channel, TCN 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 ≤ LQA transit delay.

Transit delay jitter represents variations of transit delay values. For desirable display of multicast data channel, TCN 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 ≤ 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 multicast data channel, TCN 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 ≤ LQA loss rate.

7.3 QoS extension element

QoS extension is a newly defined element for QoS management in this specification. All the extension elements used in ECTP-6 are listed below.

Table 1 - Extension Elements

Extension Element	Encoding Value (4 bits)	Length of Extension Element (bytes)
No Element	0000	0
Connection	0001	4
Error Bitmap	0010	Varied
Timestamp	0100	12
Token	0110	Varied
LO Information	0111	Varied
QoS	0101	28

The QoS extension element specifies the Maximum Segment Size (MSS) and the target values for ECTP-6 QoS parameters which are described in Section 7.2. As shown in the following figure, the QoS element has a length of '28' bytes:

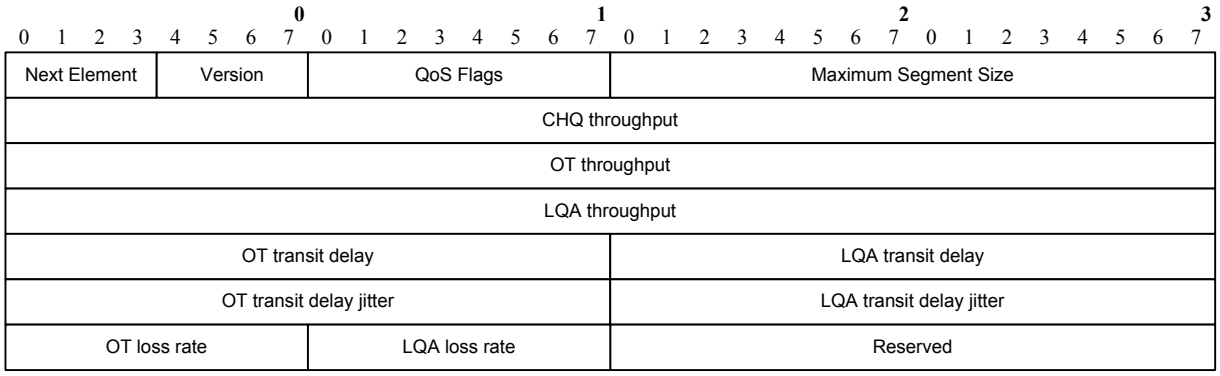


Figure 4 - QoS Extension Element

The following parameters are specified:

a) *Next Element* (4bits) – indicates the type of the next element immediately following this QoS element;

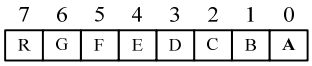
b) *Version* (4bits) – defines the current version of this element. Its current version is encoded as '0011';

1) 0001 – simplex multicast connection (for ECTP-1 and ECTP-2);

2) 0010 – duplex multicast connection (for ECTP-3 and ECTP-4);

3) 0011 – N-plex multicast connection (for ECTP-5 and ECTP-6).

c) *QoS Flags* – is a flag byte to specify if each of QoS parameters, MSS, and data channel type are used in the connection. Encoding of this byte is depicted in the following figure. If a bit is set to '1', then the corresponding QoS parameter, MSS, or data channel type will be used. The default value is '0' for each bit. If 'F' bit of the *QoS Flags* is set to '1', then the values of QoS parameters are configured for multicast data channel to sending multicast data. If 'G' bit of the *QoS Flags* is set to '1', then the values of QoS parameters are configured for multicast data channel to receiving multicast data. It is note that both 'F' bit and 'G' bit cannot set to '1' at the same time.



1) A – throughput;

2) B – transit delay;

3) C – transit delay jitter;

4) D – data loss rate;

5) E – maximum segment size (MSS);

6) F – multicast data channel for sending multicast data;

7) G – multicast data channel for receiving multicast data;

8) R – Reserved for future use

d) *Maximum Segment Size (MSS)* – represents the maximum size of an ECTP segment or packet in unit of bytes. If the 'E' bit of the *QoS Flags* is set to '1', MSS is subject to negotiation. Otherwise, the default MSS value of 1024 will be used.

e) *Throughput values* – Each value is a 32-bit unsigned integer in byte per second. The following target values are valid only if 'A' bit of *QoS Flags* is set to '1':

1) CHQ throughput – upper limit for throughput;

2) OT throughput – target throughput for desired display of multicast data;

3) LQA throughput – lower limit for throughput.

f) *Transit delay values* – Each value is a 16-bit unsigned integer in millisecond. The following target values are valid only if 'B' bit of QoS flags is set to '1':

1) OT transit delay – target transit delay for desired display of multicast data;

2) LQA transit delay – maximally allowed transit delay.

g) *Transit delay jitter values* – Each value is a 16-bit unsigned integer in millisecond. The following target values are valid only if 'C' bit of *QoS Flags* is set to '1':

1) OT transit delay jitter – target transit delay jitter for desired display of multicast data;

2) LQA transit delay jitter – maximally allowed transit delay jitter.

h) *Data loss rate values* – Each value is an 8-bit unsigned integer ranged from 0 to 100 in percentage. The following target values are valid only if 'D' bit of *QoS Flags* is set to '1':

1) OT loss rate – target loss rate for desired display of multicast data;

2) LQA loss rate – maximally allowed loss rate.

i) *Reserved* – is reserved for future use.

In the connection phase, if QoS is enabled, TCN can propose the target values of QoS parameters for sending multicast data and receiving multicast data to TS-users via CR packet. This CR packet format is as follows:

CR packet = Base Header + Connection element + QoS element + QoS element

In the above CR packet, the first QoS element is used for sending multicast data, the second QoS extension element is used for receiving multicast data. The value of 'F' bit of the *QoS Flags* in the first QoS element is '1' and '*Next Element*' byte in the first QoS element indicates the QoS element for receiving multicast data.

The QoS element is used for the TCN to inform the TS-users about the target values for QoS parameters 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 TCN. The negotiated QoS values will be announced to late-joiners via the JC packet and to existing TS-users via TSR packets.

These QoS values are also referred to in the QoS monitoring and maintenance operations.

7.4 Error Bitmap 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.

The status values are delivered to SUs via ACK packets. The error bitmap element of the ACK packet contains the status values for QoS parameters used in the connection.

The error bitmap element specified in ITU-T Rec. X.608 | ISO/IEC 14476-5 is shown below. In the figure, the '*parameter status*' byte is newly defined in this specification for QoS.

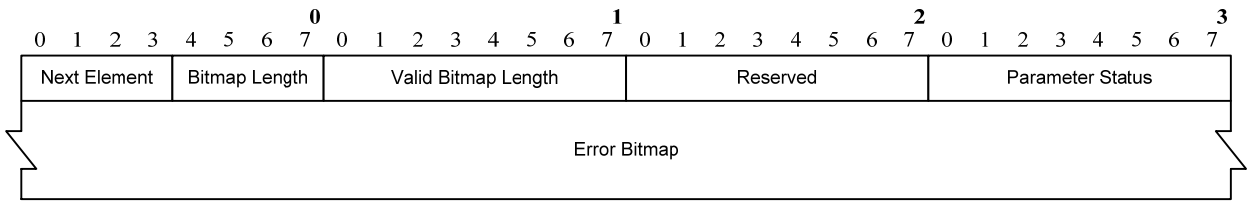
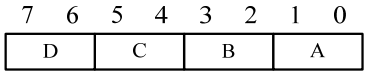


Figure 5 – Error Bitmap Extension Element

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 8.2.3.

7.5 Packets used for QoS management

Table 2 lists the ECTP-5 packets used for QoS management. Note that CSR packet is newly defined in this specification for QoS management.

Table 2 – ECTP-5 packets used for QoS management

Packet type	Extension Element					
	Connection	Error Bitmap	Timestamp	Token	LO Information	QoS
DT			O			
CR	O					O
CC						O
TSR				O	O	O
ACK		O				
JC	O					O
CSR		O				

The CR packet contains a QoS element. This is used by TCN 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 TCN with its own proposed values for QoS parameters via a CC packet. TCN will arbitrate the returned proposals, and the arbitrated values for the QoS parameters will be delivered to TS-users via TSR 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 (see Section 8.1).

The target or negotiated values will be referred to in QoS monitoring and maintenance operations. ACK packets are used to convey the status values for QoS parameters experienced at TS-user side (see Section 8.2).

The status values of QoS parameters are aggregated by TS-users along the control tree and finally delivered to SUs. Using this information, the SUs determine the connection status and periodically report it to TCN via CSR packet.

DT packet contains a Timestamp element which is used to measure an end-to-end transit delay.

7.6 Packet Format

In this Recommendation, there is 1 control packet defined.

Table 3 – ECTP-6 packets newly defined for QoS management

Full Name	Acronym	Transport	From	To
Connection Status Report	CSR	Unicast	SU	TCN

The encoding value and packet structure are shown for each of the ECTP-5 packets in Table 3. The extension elements are attached to the base header in the order specified in the table.

Table 4 – Format of ECTP-6 Packets

Packet Type	Encoding Value	Extension Elements or User Data (Packet Structure)	Length (bytes)	Operational Protocol Stage
CSR	0100 0001	Error Bitmap	48	QoS monitoring

7.6.1 Connection Status Report (CSR)

The CSR packet is used by SU to inform TCN of the current connection status. SUs can determine the current connection status exploiting parameter status values obtained from ACK packets. These values must be also reported to TCN so that TCN can perform further connection maintenance actions such as connection pause/resume and termination. An SU sends the CSR packet to TCN over the following source and destination addresses:

Source IP: IP address of SU

Source Port: local port number of SU

Destination IP: IP address of TCN

Destination Port: group port number

The CSR packet contains the 16-byte base header and the 32-byte Error Bitmap element with empty ‘Error Bitmap’ field. The base header of CSR packet must be encoded as follows:

a) *Next Element*: ‘0010’ (Error Bitmap element)

b) *CT*: ‘11’

c) *Packet Type*: ‘0100 0001’ (CSR)

d) *Checksum*: to be calculated

e) *Source Port*: local port number of SU (or Connection ID)

f) *Destination Port*: group port number (or Connection ID)

All the fields other than specified above will be set to ‘0’ and ignored at the receiver side.

The error bitmap element must be encoded as follows:

a) *Next Element*: '0000'

b) *Parameter Status*: a connection status value determined by SU: 00, 01, 10, or 11 (see Section 7.4)

All the fields other than specified above will be set to '0' and ignored at the receiver side.

8. Procedures for QoS management

In ECTP-6, the QoS management includes the following operations:

1) QoS negotiation, possibly with reservation of network resources;

2) QoS monitoring;

3) QoS maintenance.

QoS negotiation is performed in the connection creation phase, while the QoS monitoring and maintenance operations will be done in the data transmission phase.

If QoS management is enabled in the connection, the QoS monitoring and maintenance operations will be performed by default. On the other hand, QoS negotiation is enabled only when the N bit in the '*QN*' byte of the ECTP-5 base header is set to '1'.

8.1 QoS negotiation

TCN 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 multicast data channel. Each TS-user can refer to these target values for resource reservation (see Section 8.1.3). If QoS negotiation is enabled in the connection, the negotiation procedures are activated (see Section 8.1.1). The imposed or negotiated target values are subsequently used in QoS monitoring and maintenance (see Section 8.2 and 8.3).

If QoS negotiation is enabled in the connection, each TS-user can propose a new modified value for multicast data channel to send and receive multicast data in response to a target parameter value proposed by TCN. 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 multicast 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, at least in the near future, 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 this specification, TCN is required to specify via the QoS extension element whether each QoS parameter is subject to negotiation (see Section 7.3). 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 TCN.

8.1.1 Negotiation Procedures

If QoS negotiation is enabled in the connection, each TS-user responds to TCN 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 8.

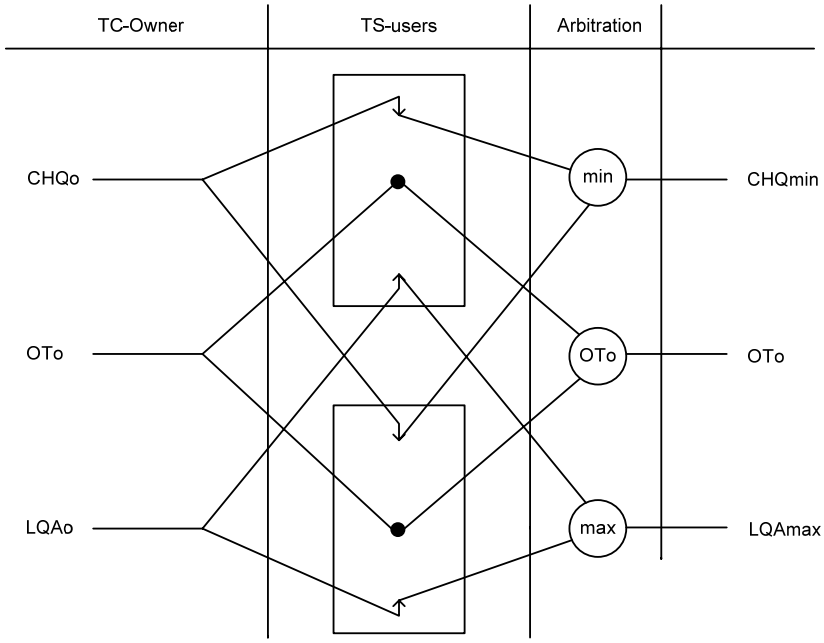


Figure 8 – QoS Negotiation Procedure

1) TCN proposes target parameter values for multicast data channel to send and receive multicast data.

   From application requirements and system and/or network capacity, TCN determines the target parameter values for multicast data data: LQAo, OTo, CHQo, where LQAo < OTo < CHQo, and then transmits a CR packet with two QoS extension elements for sending multicast data to TS-users and receiving multicast data from TS-users.

2) TS-users can modify the parameter values for multicast data channel to send and receive multicast data.

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

3) TCN arbitrates the modified parameter values for sending multicast data to other TS-users and receiving multicast data from other TS-users.

   TCN 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) TCN announces the negotiated parameter values.

   TCN announces LQAmax, CHQmin, and OT values to TS-users via TSR and JC packets.

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,

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

Note that QoS negotiation is not performed for late-joining TS-users. TCN 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 and are not modified in the data transport phase.

8.1.2 MSS negotiation

MSS represents the maximum packet size, which depends on Maximum Transmission Unit (MTU) for link layer transmissions. Typical MTU values are 1500 bytes for Ethernet, 1492 bytes for IEEE 802, 4352 bytes for FDDI, 576 bytes for X.25, and so on. The MTU determines the frame size for the link layer transmissions, and hence the MSS value.

The default MSS value of the ECTP-5 is 1024 bytes, which supports most link types except X.25. If sender and/or receiver cannot identify its MSS value, it takes the default MSS value of 1024 bytes.

In ECTP-6, if MSS negotiation is indicated (see Section 7.3), the following procedures are performed:

1) TCN writes its MSS value into the CR packet, and then transmits it to all the TS-users.
2) Each TS-user proposes its own MSS value via the CC packet. The MSS will be affected by the MTU of the local network that TS-user belongs to. If TS-user's MSS is larger than TCN's MSS, TS-user takes the TCN's MSS.

8.1.3 Resource Reservation

ECTP-6 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 RSVP model is a good match with the ECTP-6 protocol, since the resource reservation is done in an end-to-end manner. In networks where RSVP is enabled, periodic RSVP PATH messages will be delivered to receivers. In response to the PATH message, each receiver sends periodic RSVP RESV messages to the sender via the multicast data path.

If RSVP is used with ECTP-6, the target values of ECTP-6 QoS parameters will be referenced in the configuration of RSVP traffic descriptors for the RSVP TSPEC (or FLOWSPEC) contained in the RSVP PATH message. These PATH messages will be issued in accordance with CR packet and TSR packets transmitted by TCN. It is noted that the RSVP modules are managed separately from ECTP-6 in end systems. This means that the resource reservation and control functions in RSVP will only be performed only by the RSVP daemons concerned.

The differentiated service model provides differentiated classes of service for IP traffic, to support various types of applications, and specific business requirements. A small bit-pattern in each packet, in the IPv4 TOS (or DSCP) octet or the IPv6 Traffic Class octet, is used to mark a packet to receive a particular forwarding treatment, or per-hop behavior, at each network node. A common understanding of the use and interpretation of this bit-pattern is required for inter-domain use, multi-vendor interoperability, and consistent reasoning about expected service behaviors in a network. Up to the present, a specific interworking scheme between ECTP and Diffserv has not been identified.

ECTP-6 will need to utilize underlying network QoS mechanisms such as RSVP and Diffserv to establish network connections delivering the required QoS levels. However the potential use of ECTP-6 is not limited to current network QoS methods. ECTP-6 is designed to be used for QoS improvement under a variety of different QoS models in the future.

8.2 QoS monitoring

The QoS monitoring function provides SU and TCN with information about how well the connection is operating. To do this, each TS-user is required to measure the parameter values experienced and report these values back to SUs.

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 SUs via a subsequent ACK packet (see Section 7.4). Each TS-user aggregates the parameter status values from its child TS-users and delivers the aggregated values to its parent node; and to the SU consequently. These status values are further forwarded by SU to TCN periodically to inform TCN of the current connection status via CSR packet.

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

8.2.1 Generation of ACK

Each TS-user reports the parameter status values to its parent by generating ACK packets. In ECTP-6, each TS-user generates an ACK packet by *ACK_GENERATION_NUM (AGN)*. At every *AGN* number of DT packets, it aggregates the status of QoS parameters of itself and child nodes to send an ACK packet to its parent by piggybacking QoS Extension Element.

Each ACK packet conveys the measured parameter status value as described in Section 8.2.2.

8.2.2 Measurement of QoS parameter values

For 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 the time taken to receive AGN DT packets.

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 Section 8.2.3.

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 at receiving AGN DT packets.

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, SUs are required to transmit DT packets with a timestamp element. Another requirement is the synchronization of time clocks between TCN and TS-users. 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 DT packet from an SU or TCN.

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

Before receiving *AGN* DT packets, every time a new DT 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*.

8.2.3 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 (see Section 7.3).

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

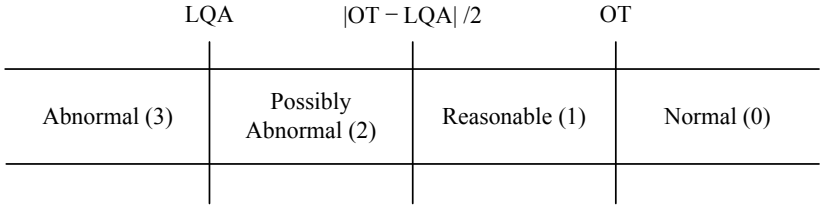


Figure 9 – Mapping of the measured value to a status value

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-6 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.

8.2.4 Reporting toward SUs and TCN

Each TS-user reports the obtained *parameter status values* to its parent via ACK packets. In this fashion, all the information about *parameter status values* will be delivered toward TCN along the tree hierarchy.

In the tree hierarchy, each parent TS-user aggregates the ACK packets from its children. This aggregation will proceed just before the parent generates its own ACK. 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 (ADN),

which *Active Descendant Number (ADN)* represents the number of descendants.

A parent TS-user 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 SUs is the same as that by TS-users. An SU also performs aggregation of ACK packets reported from its children every *AGN* DT packets.

After aggregation of ACK packets, an SU 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

An SU obtains an aggregated status value for each QoS parameter. More specifically, an SU 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.

An SU forwards the aggregated parameter status values to TCN via CSR packet. The SU sends periodic CSR packets for every *CSR_PACKET_INT* seconds to TCN. SUs may forward the monitored status information to the applications.

The monitored information is beneficial for sending applications 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 by SUs. 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 by TCN.

8.3 QoS maintenance

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, TCN will take the following QoS maintenance actions:

1) Connection pause and resume,
2) Troublemaker ejection,
3) Connection termination.

and SUs will take the following QoS maintenance actions:

1) Adjustment of data transmission rate.

Data rate adjustment is performed by SUs and 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 by TCN. These events will be announced to all TS-users via TSR packet with 'F' bit set to 1 in the base header and CT packets transmitted by TCN.

To trigger these QoS maintenance actions, TCN and SUs need 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.

8.3.1 Adjustment of data transmission rate

ECTP-6 uses a fixed-sized window-based flow control. TCN or SUs can maximally transmit the window size data packets at the rate of *Data Transmission Rate (DTR)*. ECTP-6 performs congestion control by dynamically adjusting *DTR*, based on the loss rate status values *Lvalue* (see Section 8.2.4).

Adjustment of data transmission rate is based on *threshold_rate_increase* and *threshold_rate_decrease*, which are preconfigured by TCN or SUs 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, TCN or an SU starts with *DTR* = LQA throughput, and *DTR* can be adjusted as follows:

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

At receiving every *AGN* DT packets, TCN or an SU 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

8.3.2 Connection pause and resume

Connection pause can be performed by TCN 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 TCN 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, TCN transmits periodic TSR packets with the 'F' bit set to '1' in the base header. At receiving the TSR packets with the 'F' bit set to '1' in the base header from TCN, SUs must stop sending new DT packets.

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*, TCN 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.

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

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

$$0 \leq Tweight, Dweight, Jweight, Lweight \leq 1,$$

$$Tweight + Dweight + Jweight + Lweight = 1.$$

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 SUs or TCN begin to transmit multicast data at the transmission rate of LQA. When connection resume is indicated, TSR packets will set the 'F' bit of the header to '0'.

8.3.3 Troublemaker ejection

TCN 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 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-6 protocol behavior.

8.3.4 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, TCN 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. Timers and variables

The following are timers and variables used for QoS management in this specification.

9.1 Timers

1) Connection Pause Time (*CPT*) in seconds: Once connection pause is indicated, the connection will pause during *CPT* interval (see Section 8.3.2).
2) Connection Termination Time (*CTT*) in seconds: After connection resume is indicated, if the connection pause occurs again within *CTT* interval, connection termination is triggered (see Section 8.3.4).
3) QoS Monitoring Time (*QMT*) in seconds: Each receiver measures the experienced values for QoS parameters every *QMT* interval (see Section 8.2.2).

9.2 Operation variables

1) Aggregated parameter status values: Sender aggregates the parameter status values reported from receivers, which results in *Tvalue*, *Dvalue*, *Jvalue*, and *Lvalue* (see Section 8.2).
2) ACK Generation Number (*AGN*): Each receiver generates an ACK packet by every *AGN* packets.
3) Connection Status: For triggering the connection pause/resume, all the aggregated parameter status values can be weight-averaged with the pre-configured parameter weights such as *Tweight*, *Dweight*, *Jweight*, and *Lweight*. This results in Connection Status that represents overall status of the connection (see Section 8.3.2).
4) Data Transmission Rate (*DTR*): Sender transmits multicast data at the rate of *DTR* (see Section 8.3.1).
5) Measured parameter value: Each receiver is required to measure the experienced value for QoS parameters used in the connection. This results in measured parameter value (see Section 8.2).
6) Parameter status value: The measured parameter value is mapped onto a parameter status value, which is an integer such as 0, 1, 2, or 3 (see Section 8.2).
7) Transmission Rate Decrease (*TRD*): *DTR* is decreased by *TRD* (see Section 8.3.1).
8) Transmission Rate Increase (*TRI*): *DTR* is decreased by *TRI* (see Section 8.3.1).
9) *Threshold_rate_increase*: Threshold to increase data transmission rate (see Section 8.3.1).
10) *Threshold_rate_decrease*: Threshold to decrease data transmission rate (see Section 8.3.1).
11) *Threshold_connection_pause*: Threshold to trigger the connection pause (see Section 8.3.2).

Annex A. Implementation Considerations

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

The implementation of the ECTP-6 specification shall be done based on the ECTP-5 specification and the ECTP-2 specification.

In particular, the following materials of the ECTP-5 specification will be useful for implementation of this ECTP-6:

1) Annex A: Application program interfaces;
2) Annex B: State transition diagrams;
3) Annex C: An example of system parameters values

In addition, the following materials of the ECTP-2 specification will also be useful for implementation of this ECTP-6:

1) Annex A: Interworking between ECTP and RSVP for resource reservation;
2) Annex B: Application programming interfaces.

These informative materials described above will be commonly used in the implementation of ECTP-6.

Editor's note: Needs more discussions for this section.

Bibliography

[b-IETF RFC2205] *Resource ReSerVation Protocol (RSVP) – Version 1 Functional Specification*, Internet Engineering Task Force RFC 2205, September 1997.

[b-IETF RFC2210] *The Use of RSVP with IETF Integrated Services*, Internet Engineering Task Force RFC 2210, September 1997.

[b-IETF RFC2475] *An Architecture for Differentiated Services*, Internet Engineering Task Force RFC 2475, December 1998

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