INTERNATIONAL STANDARD

ISO/IEC 14476-3

First edition
2008-04-15

Information technology — Enhanced communications transport protocol: Specification of duplex multicast transport

Technologies de l'information — Protocole de transport de communications amélioré: Spécification pour le transport duplex en multidiffusion

Reference number
ISO/IEC 14476-3:2008(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

CONTENTS

Page

1 Scope 1
2 Normative references 1
3 Definitions 1
4 Abbreviations 2
5 Conventions 3
6 Overview 3
7 Design considerations 5
7.1 Participants 5
7.2 Control tree 5
7.3 Data channels 6
7.4 Addressing 7
7.5 Tokens 8
8 Packets 8
8.1 Base header 8
8.2 Extension elements 10
8.3 Packet format 13
9 Procedures 25
9.1 Connection creation 25
9.2 Late join 25
9.3 Forward data transport 26
9.4 Token control 27
9.5 Backward data transport 29
9.6 Reliability control 29
9.7 Connection management 31
Annex A – Timers and parameters 32
A.1 Timers 32
A.2 Parameters 32
Annex B – State transition diagrams 34
Annex C – Application programming interfaces 36

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 14476-3 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*, in collaboration with ITU-T. The identical text is published as ITU-T Rec. X.607 (02/2007).

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*
- *Part 2: Specification of QoS management for simplex multicast transport*
- *Part 3: Specification of duplex multicast transport*
- *Part 5: Specification of N-plex multicast transport*

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. ECTP could possibly be provisioned over UDP.

ECTP is designed to support tightly controlled multicast connections in simplex, duplex and N-plex applications. This third part of ECTP (ITU-T Rec. X.607 | ISO/IEC 14476-3) specifies the protocol mechanisms for reliability control in the duplex case. ECTP also provides QoS management functions for stable management of the QoS of the connection users. The procedures for QoS management of the duplex case will be defined in the duplex QoS management specification (ITU-T Rec. X.607.1 | ISO/IEC 14476-4).

In the duplex multicast connection, the participants are classified into one TC-Owner and many TS-users. TC-Owner will be designated among the TS-users before the connection begins. In the duplex multicast connection, the two types of data transports are supported: multicast data transport from TC-Owner to all the other 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.

In ECTP, TC-Owner is at the heart of multicast group communications. It is responsible for overall connection management by governing the connection creation and termination, connection pause and resumption and the late join and leave operations.

The duplex multicast connection specified in ECTP-3 is targeted to the multicast applications in which the TC-Owner (a single multicast sender) transmits the data information to all the other TS-users, and some of the TS-users respond to the multicast sender with the unicast feedback data. Basically, the duplex multicast transport will be well suited to the one-to-many multicast applications that need the unicast feedback channels from some TS-users (e.g., remote education, Internet broadcasting, etc). For example, in a remote education application, the multicast sender (lecturer) transmits the data such as voice, text and image to the student group, whereas some of the students may respond to the lecturer with the unicast data like questions for confirmation.

It is noted that this duplex multicast connection can also be used for the 'some-to-many' multicast applications (e.g., a panel conferencing) in which a few of TS-users want to send multicast data to the group. In this scenario, the multicast data from the TS-users may first be delivered to the TC-Owner by unicast, and then TC-Owner will transmit the received unicast data to the group by multicast. For example, in the panel conferencing, some of the TS-users may act as a panel and transmit multicast data via TC-Owner (the conference convener) to the listener group. The detailed use of the duplex multicast connection depends on the applications of this duplex multicast transport protocol.

INTERNATIONAL STANDARD
ITU-T RECOMMENDATION

Information technology – Enhanced communications transport protocol: Specification of duplex multicast transport

1 Scope

This Recommendation | International Standard specifies the Enhanced Communications Transport Protocol (ECTP), which is a transport protocol to support Internet multicast applications over the multicast-capable IP networks.

This Recommendation | International Standard specifies the ECTP part 3 (ECTP-3) for the duplex multicast transport connection in which the participants are classified into one TC-Owner and many TS-users. The duplex multicast transport connection supports two kinds of data transport: the multicast data transport from TC-owner to all the other TS-users and the unicast data transport from TS-users to TC-Owner. A TS-user is allowed to send unicast data to TC-Owner, only if it gets a token from TC-Owner.

This Specification describes the protocol for supporting the duplex multicast transport, which includes the connection management (establishment, termination, pause, resumption, user join and leave) and the reliability control mechanisms for the multicast and unicast data transport. In particular, the protocol operations for the multicast data transport from TC-Owner to the TS-users will be designed with the congruency of the simplex multicast transport protocol (ECTP-1), as specified in ITU-T Rec. X.606 | ISO/IEC 14476-1.

2 Normative references

The following Recommendations and International Standards contain provisions which, through reference in this 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 and Standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU maintains a list of currently valid ITU-T Recommendations.

- ITU-T Recommendation X.601 (2000), *Multi-peer communications framework.*
- ITU-T Recomendation X.602 (2004) | ISO/IEC 16513:2005, *Information technology – Group management protocol.*
- ITU-T Recommendation X.605 (1998) | ISO/IEC 13252:1999, *Information technology – Enhanced communications transport service definition.*
- ITU-T Recommendation X.606 (2001) | ISO/IEC 14476-1:2002, *Information technology – Enhanced communications transport protocol: Specification of simplex multicast transport.*
- ITU-T Recommendation X.606.1 (2003) | ISO/IEC 14476-2:2003, *Information technology – Enhanced communications transport protocol: Specification of QoS management for simplex multicast transport.*

3 Definitions

This Recommendation | International Standard is based on the following definitions, which were specified in Enhanced Communications Transport Service (ITU-T Rec. X.605 | ISO/IEC 13252).

a) Transport connection: Simplex, duplex and N-plex;

b) TC-Owner and TS-users.

This Recommendation | International Standard uses the following terminologies specified in Enhanced Communications Transport Protocol: part 1 (ITU-T Rec. X.606 | ISO/IEC 14476-1).

a) control tree;

b) parent and children;

c) TO (Top Owner):

TO is a single sender of multicast data packets, which can transmit multicast data to the other TS-users, and it manages overall operations of ECTP-3. The TO will be designated among the TS-users before the connection begins, and the TO will do the functions of TC-Owner;

d) LO (Local Owner):

An LO is located on the control tree of ECTP-3. One or more LOs could be designated for scalable error recovery and status monitoring in ECTP-3. An LO is also a TS-user, which can also receive the multicast data from TO. LOs will be configured as a parent of the local groups through the control tree configuration in ECTP-3; and

e) LE (Leaf Entity):

An LE is a leaf node on the ECTP-3 control tree. It is a TS-user in the ECTP-3 connection, and it can receive multicast data sent by TO.

This Recommendation | International Standard also applies the following definitions:

a) SU (Sending TS-user):

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

b) Token:

It represents the right for a TS-user to transmit data. The TS-user who has a token is called a Sending TS-user (SU). The tokens are managed by TO.

c) Forward data channel:

It represents the multicast data channel from TO to the group members. TO 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 packets flow from an SU to TO. An SU can send unicast data to TO over IP unicast address.

4 Abbreviations

For the purposes of this Recommendation | International Standard, the following abbreviations apply, which includes the ECTP-3 packets:

ACK	Acknowledgment
CC	Connection Creation Confirm
CR	Connection Creation Request
CT	Connection Termination Request
DT	Data
HB	Heartbeat
HBACK	Heartbeat Acknowledgment
JC	Late Join Confirm
JR	Late Join Request
LE	Leaf Entity
LO	Local Owner
LR	User Leave Request
ND	Null Data
RD	Retransmission Data
SU	Sending TS-user
TC	Tree Join Confirm
TGC	Token Get Confirm
TGR	Token Get Request

TJ	Tree Join Request
TO	Top Owner
TRC	Token Return Confirm
TRR	Token Return Request
TS	Transport Services

5 Conventions

In this Recommendation | International Standard, the capital characters are used to represent a 'packet' of ECTP-3 (e.g., *CR* for Connection Creation Request packet), and the capital and italic characters are used for 'timers' or 'variables' used in ECTP-3 (e.g., *CCT* for Connection Creation Timer, and *AGN* for ACK Generation Number).

6 Overview

The Enhanced Communications Transport Protocol (ECTP) is a transport protocol designed to support Internet multicast applications. 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.

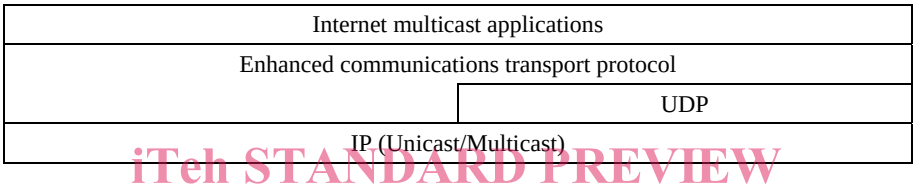

Figure 1 – ECTP model

This Recommendation | International Standard describes the protocol specification of the ECTP Part 3 (ECTP-3) for the duplex multicast connection. The duplex multicast connection is used for supporting multicast data transport between the participants that are classified into a single TC-Owner (TO) and the other TS-users. A duplex multicast connection supports the two types of data channels between the participants: *multicast data channel* (sent by TO toward all the other group members) and *unicast data channel* (sent by a TS-user to TO). Such a TS-user is called Sending TS-user (SU) in the ECTP-3.

Figure 2 illustrates these two types of data transport channels used in the duplex multicast connection. As shown in the figure, TO can transmit multicast data to the other TS-users over IP multicast (group) address. Some SUs may send unicast data to TO. The SU must first get a token from the TO before sending the unicast data.

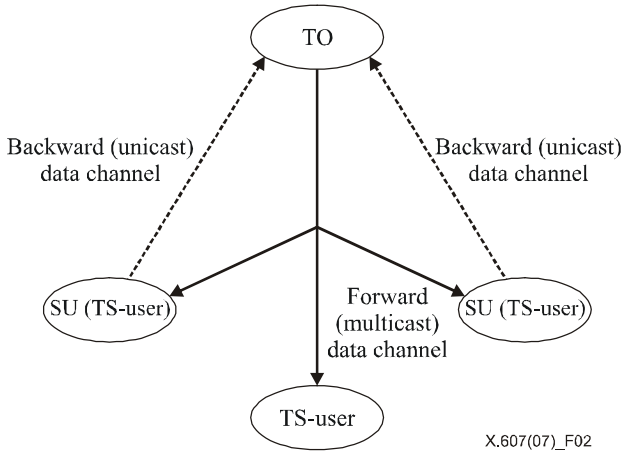

Figure 2 – Data transport in ECTP-3

To establish a duplex multicast connection, TO transmits a Connection Creation Request (CR) packet to the group. The CR packet contains the connection information including general characteristics of the connection. In particular, the CR packet must indicate that the connection type is the duplex multicast transport. Each TS-user who wants to participate in the connection will respond to the TO with a Connection Creation Confirm (CC) packet. The connection creation operation will be completed when a predetermined *CCT* timer expires.

During the connection creation phase, a logical control tree is configured between TO and TS-users, or between TS-users for providing the scalable reliability control. With the root of the TO, the control tree defines a parent-child relationship between any pair of two TS-users. The parent TS-user is called Local Owner (LO). Based on the control tree, the error recovery will be performed. To configure a control tree, each TS-user sends a Tree Join Request (TJ) message to a candidate parent node that has already been connected to the tree. The parent node will respond to the promising child TS-user with the Tree Join Confirm (TC) message. In this way, the control tree will gradually be expanded from the root toward the leaf nodes.

Some of the prospective TS-users may join the connection as late-joiners. The late-joining TS-user participates in the connection by sending a Late Join Request (JR) message to TO. In response to the JR message, TO sends a Late Join Confirm (JC) message to the TS-user. The late-joiner TS-user will also join the control tree by using the TJ and TC messages. For this purpose, the JC message of TO may include the information about the prospective parent LO node for the late-joiner. The late-joining TS-user may try to connect to the prospective LO node so as to configure the control tree.

After the connection is established, the data transmission phase starts. ECTP-3 protocol supports two types of data channels: the forward multicast channel from TO to the group and the backward unicast channel from the TS-user to TO. ECTP-3 provides the reliable data transport with error recovery, in which all the Data (DT) packets will be recovered by the parent on the tree.

In the forward multicast data transmission, TO can begin the multicast data transmission to the group by using the IP multicast address and group port number. The multicast data packets sent by TO will be sequentially segmented and transmitted by DT packets to the receiving TS-users. The TS-users will deliver the received DT packets to the upper-layer application in the order transmitted by TO.

For the forward multicast data channel of TO, the error control will be performed based on the local group defined by the ECTP control tree. If a child node detects a data loss, it sends a retransmission request to its parent via ACK packets. Each child generates an ACK packet every *ACK Generation Number* (*AGN*) data packets. That is, an ACK packet is generated for the *AGN* data packets of TO. An ACK message contains a 'bitmap' to indicate which data packets have been received or not. In response to an ACK packet, each parent LO may retransmit the RD packets to its children.

In the forward multicast data transport, the Heartbeat (HB) and Heartbeat ACK (HBACK) packets are used between a parent and children for the control tree maintenance. A parent transmits HB packets to the children every *HB Generation Time* (HGT). The HB contains which child must respond to this HB packet with the HBACK packet. The corresponding child will send a HBACK packet to the parent. The HB packet may also be used by the parent to calculate the local Round Trip Time (RTT) for the group. For this purpose, the HB and HBACK packets contain a timestamp.

For the backward unicast data transport, a certain TS-user in the connection may get a token from TO by sending a Token Get Request (TGR) message. The TO will then respond to the TS-user with the Token Get Confirm (TGC) message that contains a *Token ID*. Accordingly, the total number of tokens in the connection is controlled by TO. Token ID is used to identify the sender of the unicast DT packets at the TO side. The TS-user who has a token is called Sending TS-user (SU).

The SU can send unicast DT packets to TO. For the error recovery and congestion control, the HB and HBACK packets are exchanged between SU and TO. The SU sends an HB message to TO. The TO then responds with the HBACK packet that contains the acknowledgement information, as done in ACK packets in the forward multicast channel. It is noted that the HBACK is used for retransmission request in the backward channel.

After completing the unicast data transmission, the SU will return the token to the TO by sending a Token Return Request (TRR) message. TO will respond to the SU with a Token Return Confirm (TRC) message.

The connection management operations are taken in the connection: user leave, the connection pause and resumption, and connection termination. In the User Leave operation, a participating TS-user may leave the connection by sending a User Leave Request (LR) message to the parent. In a certain case, the parent may enforce a specific child node to leave the connection by sending the LR message, which is called the troublemaker ejection. The TO may temporarily pause and resume the connection. In the connection pause period, the TO will send Null Data (ND) packets to the group. After the TO has completed the data transport, it may terminate the duplex connection by sending a Connection Termination Request (CT) message to the group.

7 Design considerations

In this clause, some considerations for ECTP-3 are described.

7.1 Participants

All participants to a duplex multicast connection are TS-users and one of them functions as TC-Owner.

TC-Owner:

In a duplex multicast connection the TC-owner is responsible for connection management including connection creation/termination, late join, connection maintenance, and token management.

TS-user (Transport Service User):

A duplex multicast connection has one or more TS-users who can receive the multicast data from the TC-Owner. Some of the TS-users can send unicast data to the TC-Owner.

A TS-user can become TO, LO or LE, depending on its role.

TO (Top Owner):

A duplex multicast connection has a single TO, which corresponds to the TC-Owner. The TO is responsible for the overall operations required for connection management including connection creation and termination, control tree creation, late join, and connection maintenance. TO is also a single sender of the forward multicast data channel. Only the TO is allowed for sending the original multicast data to the other participants.

LO (Local Owner):

In the duplex multicast connection, an LO is a TS-user who is responsible for error recovery to the local group by retransmission of data. On the control tree hierarchy of ECTP-3, an LO is a parent node and has its children nodes. Note that an LO is also a TS-user. That is, an LO also receives multicast data from the TO. In ECTP-3, a TS-user may act as an LO in the connection, or some designated LOs may be used for the error recovery in the connection. It depends on the deployment of ECTP-3.

LE (Leaf Entity):

In the duplex multicast connection, an LE represents a leaf node on the control tree. Each LE is a TS-user that receives the multicast data from the TO.

A TS-user can become SU when it obtains a token from TC-Owner.

SU (Sending TS-user):

An SU is a TS-user who can send unicast data to TO. In the duplex multicast connection, a TS-user becomes an SU when it has a token and it can thus transmit unicast data to TO.

7.2 Control tree

A duplex multicast connection may configure a control tree for scalable reliability control as shown in Figure 3:

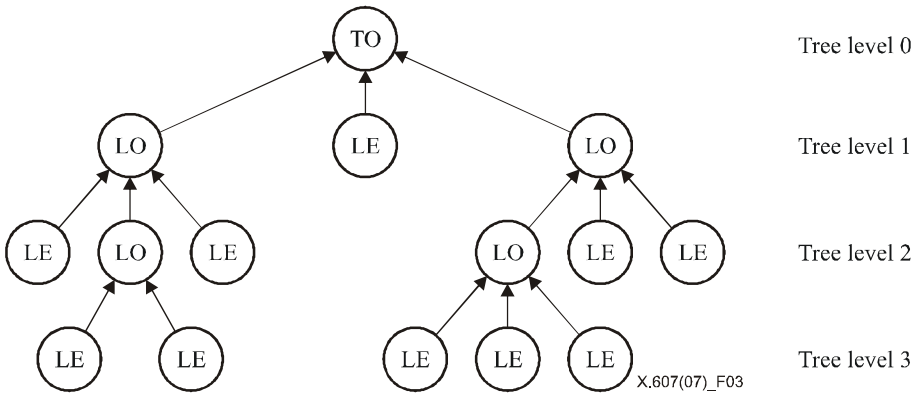

Figure 3 – Control tree in ECTP-3

In the ECTP-3 control tree, TO is on the top of the tree, which is in the Tree Level 0. An LO is a parent node on the tree and has one or more children. A TS-user, not designated as LO, is called a Leaf Entity (LE), which cannot have its children. Such a control tree will be configured in the connection creation phase.

Error recovery in ECTP-3 will be performed within each local group defined by the control tree. A child can request retransmission to its parent LO. In response to the request, the parent LO will retransmit the data packets to the children, if it has them in the buffer. An LO is also a TS-user, and it thus receives the multicast data from the TO. The control tree is applied only for forward multicast data channel. The control tree does not apply to the backward unicast data channel.

7.3 Data channels

In ECTP-3, the two types of data channels are used: forward and backward data channels.

7.3.1 Forward data channel

The forward data channel is used for TO to send multicast data to the other members. The forward multicast data channel can also be used for an LO to send Retransmission Data to its children users.

The forward data channel address consists of the group (multicast) IP address and the group port. TO sends multicast data via DT packets by using the forward data channel address. TO and LOs can also retransmit multicast data via RD packets by using the forward data channel address.

Figure 4 illustrates the use of the forward multicast data channels in ECTP-3.

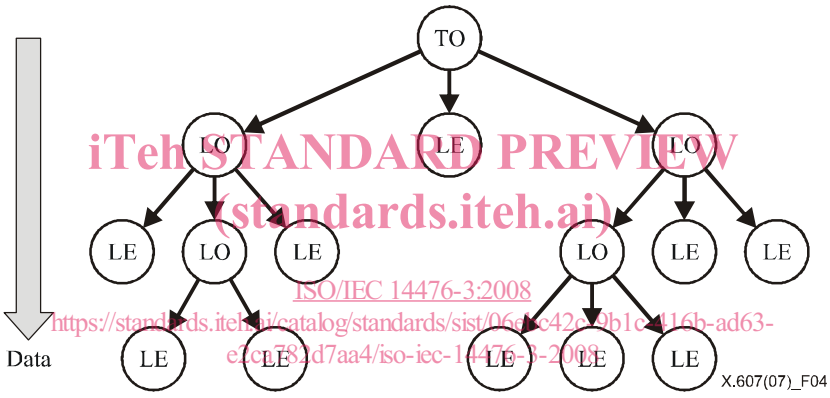

Figure 4 – Forward data channels and control tree in ECTP-3

7.3.2 Backward data channel

The backward data channel is used by a Sending TS-user (SU) to send unicast data to TO. The backward channel address consists of the IP address of TO and the 'group' port.

Figure 5 illustrates the use of the backward unicast data channels in ECTP-3.

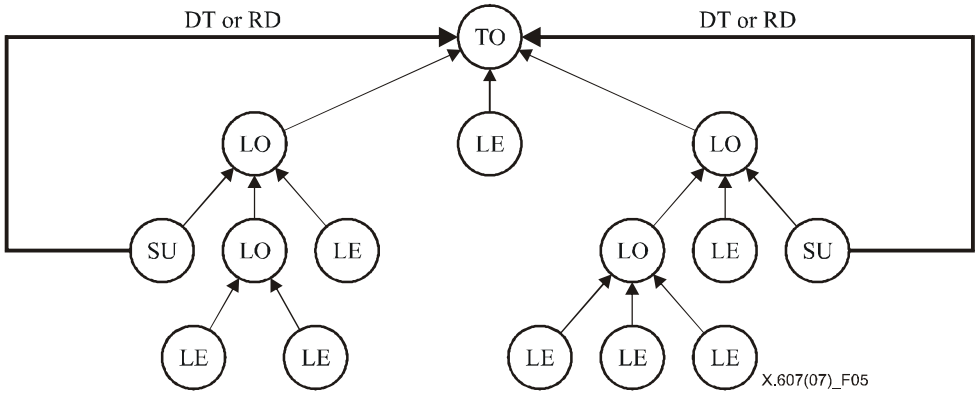

Figure 5 – Backward data channels in ECTP-3

Each SU must send unicast data via DT and RD packets to TO by using this backward data channel address as the destination address. On the other hand, TO must bind its backward data channel address to receive the unicast data from any SU in the connection.

7.4 Addressing

In ECTP-3, each packet uses the following types of IP addresses and port number for its source and destination address:

a) group IP address and local IP address;

b) group port and local port.

7.4.1 Group and local IP addresses

The group IP address is the IP multicast address (e.g., Class D address for IPv4), whereas a local IP address represents the unicast IP address for each of the ECTP participants: TO, LOs and LEs.

The group IP address is used as the destination address of the packets that need to be multicast by TO and LOs. For example, the CR and DT packets of TO will use the group IP address as the destination address of the associated IP packets. Each LO also uses the group IP address as the destination address of the RD and HB packets.

The local IP address of each participant is used as the source and destination IP address for the unicast packets, and also the source address for the multicast packets.

It is noted that the group IP address and the local IP address of TO must be announced to all the prospective participants via an out-of-band signalling such as Web announcement.

7.4.2 Group and local ports

The group port represents the port number that has been announced to all of the ECTP-3 participants before the connection. In ECTP-3, the group port will typically be used as the 'destination port' of the ECTP-3 multicast packets transmitted by TO or LOs, such as CR and DT. That is, each TS-user should bind to the group IP address and port so as to receive the relevant ECTP-3 multicast packets.

The group port number is also used by SU to send unicast data to TO. That is, TO will bind to the local port with its local IP address so as to receive the unicast data from any SU. In particular, the group port is also used as the destination port of the packet that requests a certain action, such as Late Join.

On the other hand, in the other cases that are not described above, the ECTP-3 packet will use the local port number as source and/or destination ports. For example, in response to the Late Join Request (JR) from a TS-user, the TO will respond with the Late Join Confirm (JC) message that use the local port of the TS-user as the destination port.

The detailed use of the local IP address and port is specified below for each of the ECTP-3 packets.

7.4.3 Addresses of data channels

In ECTP-3, all the data packets use the group port number as the destination port. Accordingly, before the connection creation, the following information must be announced to all of the ECTP-3 participants via an out-of-band signalling such as Web announcement.

a) group IP address and group port;

b) local IP address of TO.

Figure 6 describes the use of IP address and port for the forward and backward data channels. The forward multicast data packets use the group IP address and port number as the destination address of the data packets, whereas the backward data packets use the local IP address of TO and the group port number as the destination address.

The detailed use of the group and local addresses for the other packets will be specified later.