INTERNATIONAL TELECOMMUNICATION UNION

ITU-T X.6

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STANDARDIZATION SECTOR
OF ITU

(03/93)

PUBLIC DATA NETWORKS: SERVICES AND FACILITIES

MULTICAST SERVICE DEFINITION

ITU-T Recommendation X.6

(Previously “CCITT Recommendation”)

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation X.6 was prepared by the ITU-T Study Group VII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR, or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

CONTENTS

Recommendation X.6

MULTICAST SERVICE DEFINITION

(Helsinki, 1993)

The establishment in various countries of packet switched public data networks creates the need to produce Recommendations to facilitate the provision of point-to-multipoint (multicast) data services.

The CCITT,

considering

that a need has been identified whereby a user sending the same data unit to multiple remote users could realize transmission and processing efficiencies by using multicast services;

unanimously declares

that the multicast service definitions and capabilities operate in accordance with this Recommendation.

1 Introduction

This Recommendation describes the service definitions and capabilities of a multicast service.

This Recommendation provides a common model for the description of the service elements, defines the terminology and describes a set of capabilities which may be provided by such a service. This Recommendation does not specify the interface specifications or the protocol elements that would be used to provide the service.

2 Scope and field of application

The multicast service described in this Recommendation is a connection-oriented multicast service, in the sense that the multicast user must first establish a connection (virtual call or permanent virtual circuit) before it is able to send or receive any multicast data. The multicast service may be real time, that is, with predictable delay characteristics.

The term connection as applied to the multicast service differs from point-to-point service in two ways:

1) the user connection terminates within the network, in an entity called the multicast server;

2) from a user's perspective, there are more than one remote users on this connection.

The multicast service described in this Recommendation may be used by a broad range of applications. Some typical examples are:

1) applications where a continuous stream of data, such as messages, status, events and process data, needs to be distributed to multiple destinations;

2) applications where data are produced with time constraints – data may have to be delivered to multiple destinations within a specified time, after which they may no longer be valid or useful;

3) applications where a data base is distributed, for instance, to provide greater availability and/or to spread the traffic loading.

The multicast service is designed to work over a variety of transmission technologies, such as packet switched data networks, local area networks, with multicast addressing, and satellite networks.

3 Definitions

For the purpose of this Recommendation, the following definitions apply:

multicast service: Is one in which a single data unit transmitted by a source is received by multiple destinations; it is a one-in, many-out service[1)].

multicast group: A set of members participating in the packet multicast service. The multicast group is defined by a rule (or set of rules) which identifies a collection of members implicitly or explicitly. This rule may associate members for the purpose of participating in a call, or may associate members who do not participate in data transfer but do participate in management, security, control, and accounting for the multicast group.

multicast call: The relationship that exists between the members of a multicast group for the purpose of transferring data. More than one multicast call may exist in a multicast group. A multicast call establishes an active group.

active group: Those members of the multicast group that are participating in a particular multicast call at a given instance of time.

invoked group: Those members of the multicast group with which communication is attempted in a particular multicast call.

open group: A special multicast group which does not have pre-defined set of members. Any user may participate in an open group.

group controller: The member (or third party) responsible for the multicast group creation and membership control.

call initiator: The member (or third party) authorized to initiate a multicast call. More than one member may initiate multicast calls.

one-way: Mode of communication. See 5.1.1.

two-way: Mode of communication. See 5.1.2.

n-way: Mode of communication. See 5.1.3.

multicast server: A logical entity which provides the packet multicast service to the members.

participant: A member of a multicast group participating in a particular multicast call at a given time.

capability: Capabilities allow a participant or member to perform certain functions as part of managing or participating in multicast data transmission.

concentrate: Transmissions from multiple sources are received by a single receiver.

The following terms are defined in Recommendation X.200:

- Protocol data unit.
- Service data unit.

4 Multicast service model

The multicast service model (Figure 1) shows a multicast group as consisting of members that participate in multicast communication using an immediate entity called the multicast server. The multicast server is a single logical entity which provides the multicast service to all members.

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1) A multicast service is intended to mean a service in the sense of services specified in Recommendation X.1/X.2. There is no intended relasionship to an OSI service.

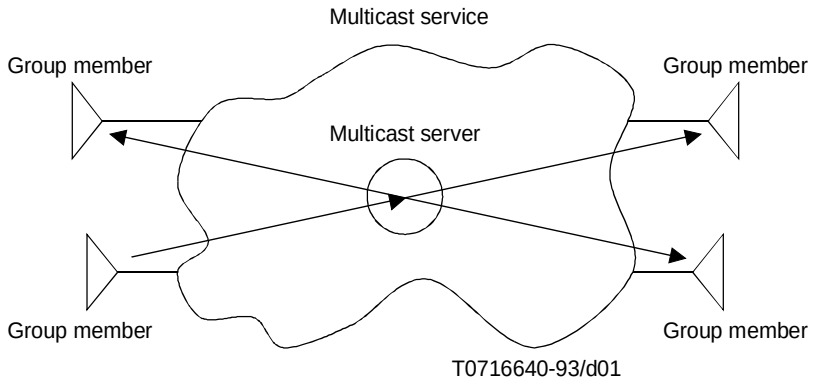


FIGURE 1/X.6

Multicast service model

The logical relationship between the members of a multicast group, for the purpose of transferring data, is called a multicast call. In practice, a multicast call may be logically composed of *n* point-to-point connections, one between each member and the multicast server, as shown in Figure 1.

Some applications for multicast may use multicast groups as a management and control mechanism to provide the multicast service. In other multicast applications, emphasis may be on the call itself and a group may exist only for the duration of a single call.

A multicast group is an entity that defines a domain in which members may participate in multicast communication and precludes communication with users not in the group. A multicast group is defined by a rule specific to the environment, protocols, Administrations, networks, and situations for which multicast communications are being used. It may be created by a static administrative means, dynamic on-line means, or may be implicit and unchangeable because of the nature of the service offered.

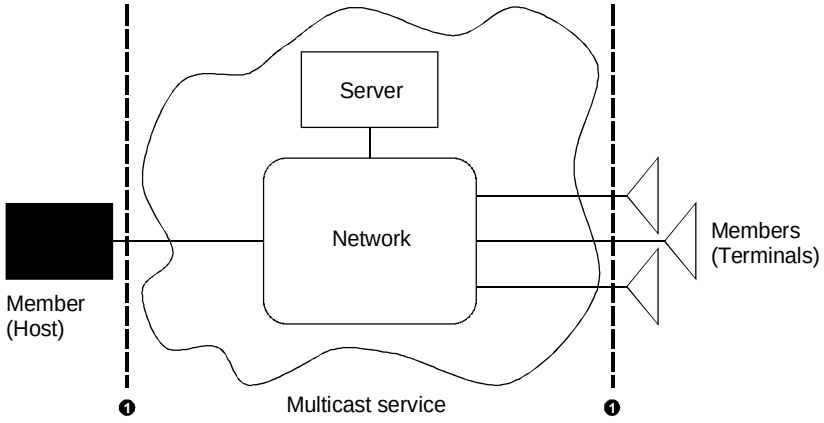
An open group is a multicast group which does not have a pre-defined set of members. Any user may attempt to participate in an open group. The multicast service may support multiple different open groups with different rule sets for inclusion and exclusion of members. “Open group” is a part of the rule for group membership, e.g. “the group is open”. Open groups can be set up for different purposes, such as different new services, catalogue ordering, etc.

The multicast model depicts the multicast service as a single logical entity (that is, the multicast server). In practice, the multicast server may be single or be distributed, and may reside inside or outside a network. The server (or servers when distributed) may be on the same network as the members accessing it or on different networks. Figure 2 (parts a, b and c) provides some implementation examples. These examples are not meant to be exhaustive and other implementations are possible.

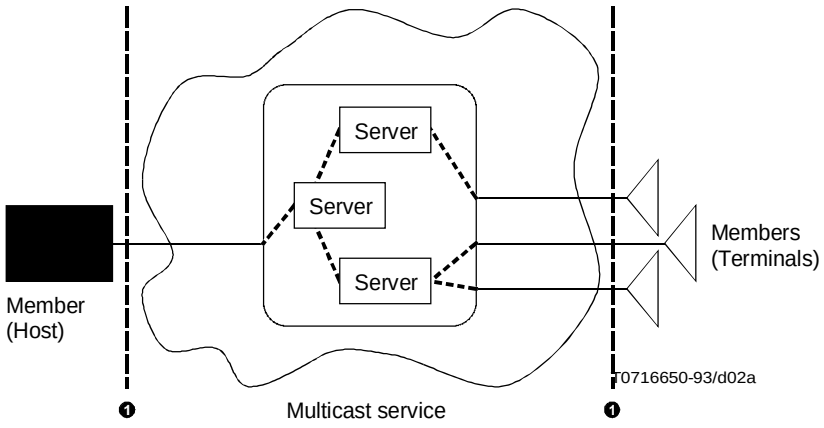
The multicast service may require an inter-networking capability to allow multicast servers on separate networks to communicate with each other [Figure 2 c)]. The server-to-server communication is provided in such a manner that the individual members perceive the service as being provided by a single logical entity (the multicast server).

A member may belong to multiple multicast groups. Figure 3 shows an example in which g is a member of groups 1 and 2.

A multicast group may have simultaneous calls. Figure 3 shows two multicast calls (1 and 3) being used in group 1. The multicast calls may be used, for example, by a member to transfer multiple logical streams of data, or they may be initiated by different members of the multicast group.



a) Server outside the network

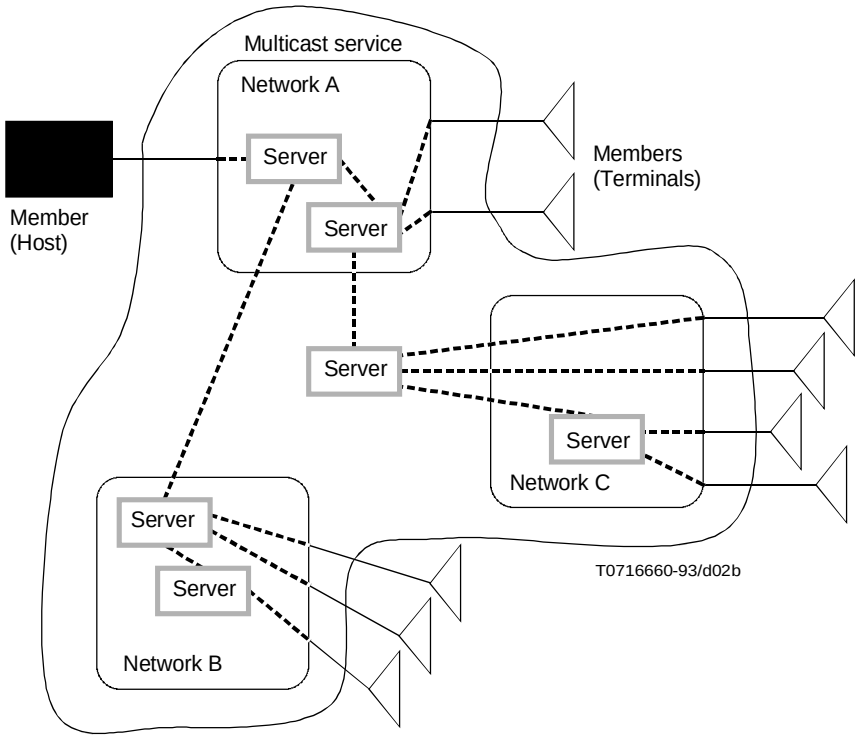


b) Server inside the network

❶ Indicates boundary of the multicast service as seen by the user.

FIGURE 2/X.6

Examples of server implementation



c) Servers in multiple networks and outside of networks

FIGURE 2/X.6 (*end*)

Examples of server implementation

The set of members participating in a multicast call at a given time is called the active group. A member participating in a particular multicast call is called a participant in that call. For example, the active group for multicast call 3 in Figure 3 contains participants (a, c, ..., g); if participant a leaves the call at some later time, the active group of participants for multicast call 3 would then contain (c, ..., g).

Multicast communication to a subset of members of a multicast group may be accomplished by one of the following methods:

1) creating a new multicast group containing the subset of members of the original group;

2) changing an existing multicast group rule set, which implies changing the membership of an existing group; or

3) using an inclusion list or exclusion list with the multicast call. The list specifies a set of members that are authorized (not authorized) to join the multicast call. Note that exclusion can occur at any time (i.e. during both call setup and data transfer).

Figure 3 shows an example in which member b is not participating at that time in multicast call 3.

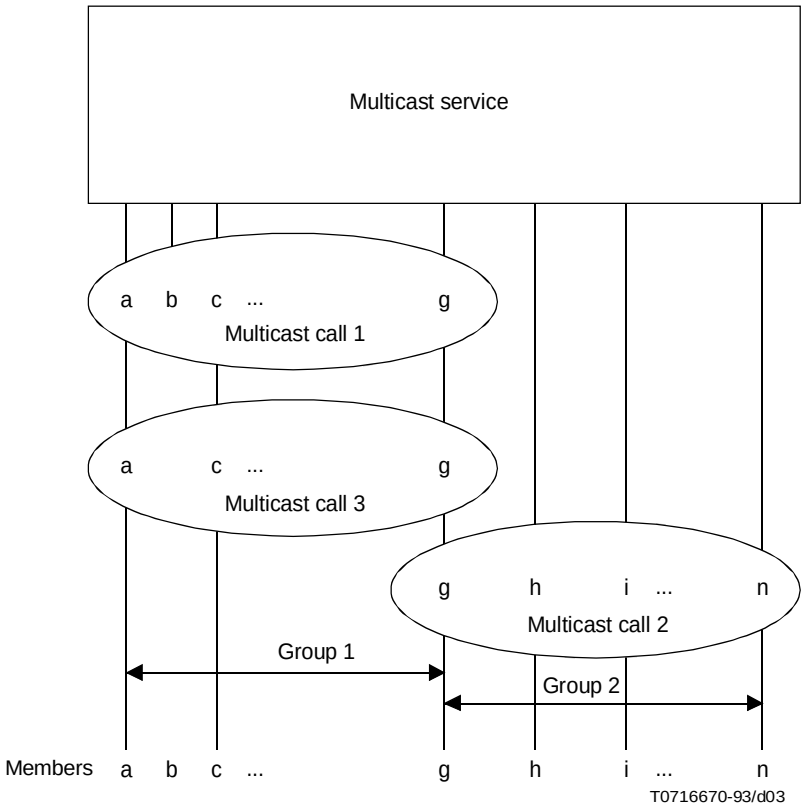


FIGURE 3/X.6

Examples of call configurations

5 Service overview

The multicast service, in general, provides the ability to establish a multicast relationship (i.e. multicast call) between the members of a group and allows them to participate in real-time data transfer.

As shown in Figure 4 real-time implies that a data unit (x) received by the multicast service at time t, will be delivered at least to those members of the multicast group that were participating in the multicast call at that time (i.e. the active group); members that join the multicast call after time t may or may not receive this data unit.

5.1 Data transfer overview

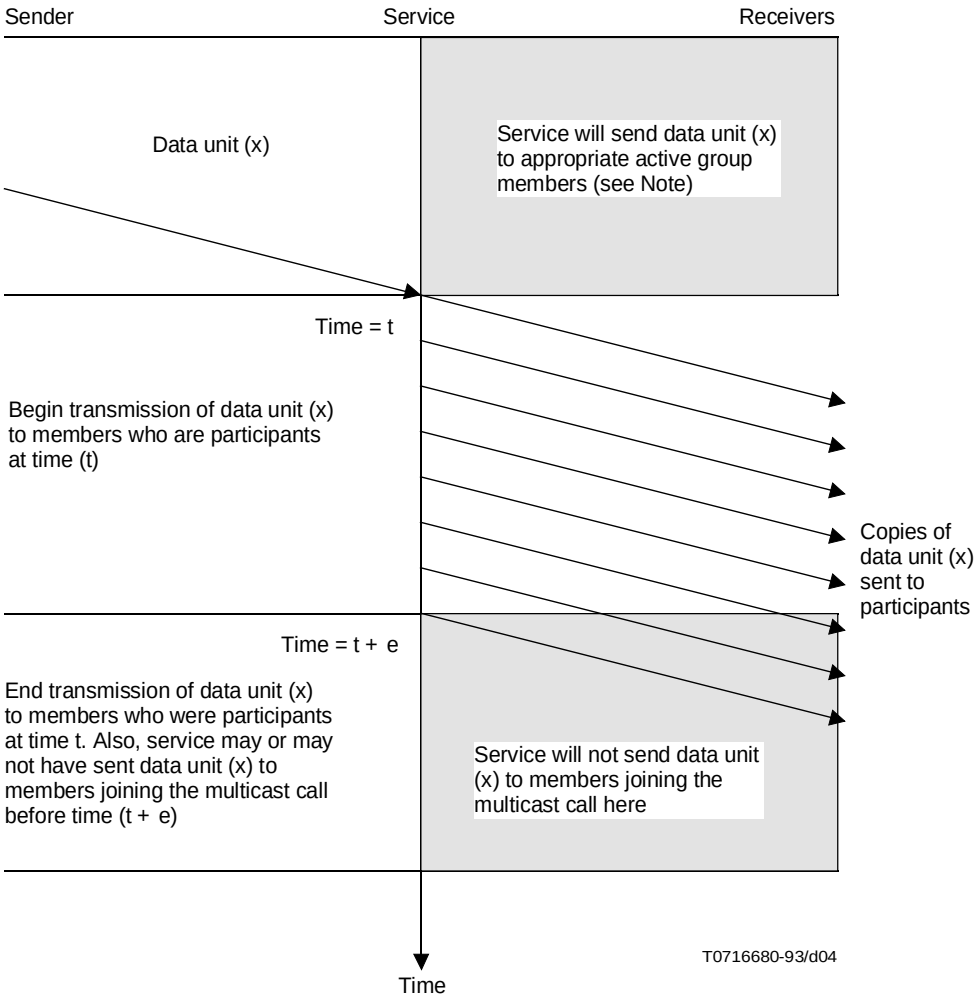
Several types of data transfer are possible. These types appear to be distinct, but actually can form a continuum of different multicast communications methods. Not every realization of a multicast service will provide all of these data transfer types, and may not support all of the options described.

In general, it will not be useful for a participant sending data to receive a copy of its own transmission. However, specific realizations may wish to include this as an option to meet the needs of some applications.

The use of the term "optionally" to describe data transfer rules in the following three subclauses has two implications:

1) protocols which provide the multicast service may choose to support this data transfer rule;

2) protocols which support this data transfer rule may make it optional on per-call, per-packet, per-group, per-interface, or other basis, as appropriate to meet the needs of some applications.



NOTE – Appropriate active group members depend on the direction of data transfer.

FIGURE 4/X.6

Real-time multicast

5.1.1 One-way

In one-way data transfer, transmission is simplex. One or more participants are defined as senders and the rest of the participants are defined as receivers. The following rules apply to one-way data transfer:

1) a receiver may not send data;

2) any data sent by a sender are transmitted to all receivers;

3) optionally, data sent by a sender will be transmitted to other senders participating in the same call;

4) optionally, data sent by a sender will be transmitted back to it.

See Figures 5 and 6.

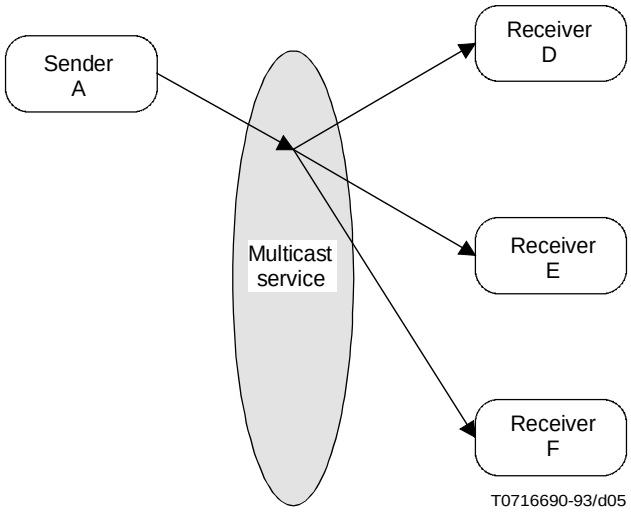
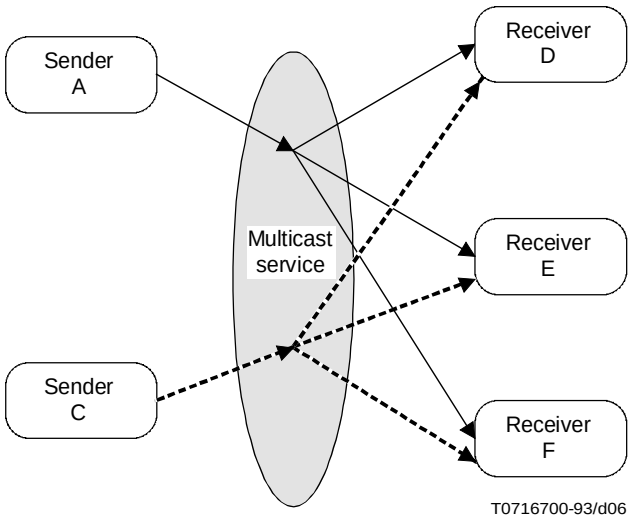


FIGURE 5/X.6

One-way data transfer (simple case)



NOTE – Dashed lines indicate a second sender in the same multicast call.

FIGURE 6/X.6

One-way data transfer

5.1.2 Two-way

In two-way data transfer, transmission is duplex, but some transmissions are concentrated while the other transmissions are multicast. One or more participants are defined as sender/receivers, because their primary function is sending, and the rest of the participants are defined as receiver/senders, because their primary function is receiving. The following rules apply to two-way data transfer:

1) any data sent by a sender/receiver are transmitted to all receiver/senders.

NOTE – This is a multicast transmission;

2) any data sent by a receiver/sender are transmitted to all sender/receivers.

NOTE – This is a concentrated transmission;

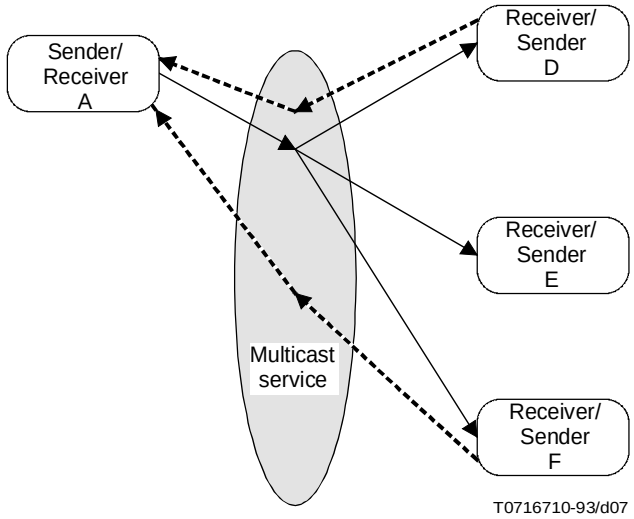
3) optionally, data sent by a sender/receiver will be transmitted to other sender/receivers participating in the same call;

4) optionally, data sent by a sender/receiver will be transmitted back to it;

5) optionally, a receiver/sender will be able to direct particular data for transmission to a particular sender/receiver.

See Figures 7 and 8.

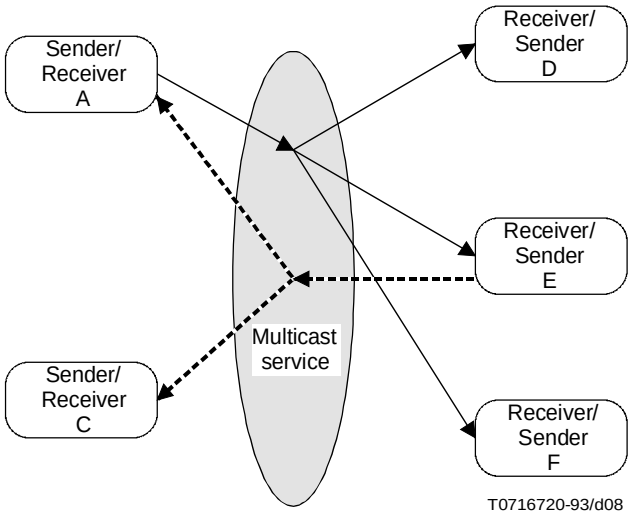
NOTE – For entirely concentrated transmission, one-way data transfer with multiple senders could be used.



NOTE – Dashed lines indicate examples of return traffic from receiver/senders in the same multicast call.

FIGURE 7/X.6

Two-way data transfer (simple case)



NOTE – Dashed lines indicate examples of return traffic from receiver/senders in the same multicast call.

FIGURE 8/X.6

Two-way data transfer

5.1.3 n-way

In *n*-way data transfer, transmission is duplex, and all transmissions are multicast (i.e. no transmissions are concentrated). All participants are data transmission peers. The following rules apply to *n*-way data transfer:

1) any data sent by a participant are transmitted to all other participants;

2) optionally, data sent by a participant will be transmitted back to it.

See Figure 9.

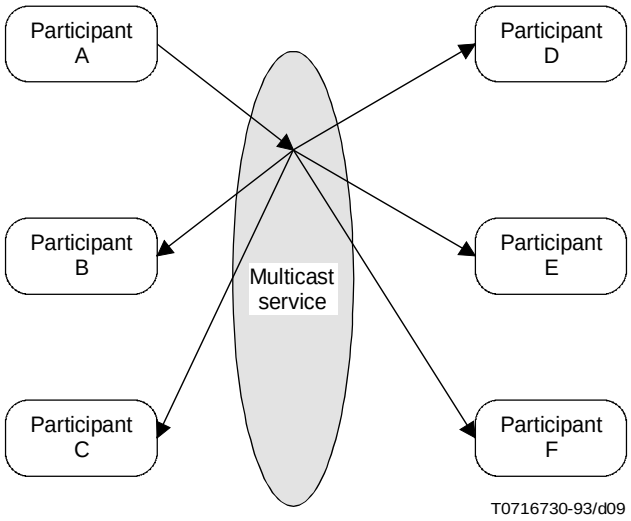


FIGURE 9/X.6

N-way data transfer

5.2 Signalling and control overview

The multicast service may provide many signalling and control capabilities, such as the ability to create multicast groups, control group membership, dynamically establish and terminate multicast calls, provide notifications when members join and leave the active group, and other status information.

The signalling and control capabilities of 6.2, 6.4, 6.5, 6.6 and 6.7 may be applied on a recursive basis to create, operate, terminate and control a sub-call among a sub-group of participants involved in a multicast call. The same attributes and capabilities are allowed for a sub-call as for any other multicast call. Attributes not specified for a sub-call may be inherited from the super-call. Certain capabilities applied to the super call would be applied to all created sub-calls (e.g. terminating the super-call terminates all associated sub-calls) whereas other capabilities apply only to a single call at a specific level (e.g. joining a call does not result in the participant joining any sub-calls). Data transfer then also identifies which (sub) call it pertains to.

Subclauses 6.1, 6.2, 6.4, 6.5, 6.6 and 6.7 describe the multicast signalling and control capabilities and their service attributes.

NOTE – Some (many) of the signalling and control capabilities may be provided entirely by static, administrative means to facilitate the introduction of the service for existing users, or additionally, by dynamic on-line methods to offer more flexibility and control to the users. Which of the signalling and control capabilities are provided by static means and which by dynamic means shall be dependent on the service provider.

6 Service capabilities

The following capabilities may be provided by the multicast service:

- *Multicast Group Creation and Membership Control* (6.1): This capability is used to create (or destroy) a multicast group as an abstract entity, and to add and remove members from the multicast group;
- *Multicast call* (6.2): This capability is used to establish a relationship between the multicast group members for the purpose of transferring data;
- *Data transfer* (6.3): This capability provides the multicast data transfer;
- *Leave call* (6.4): This capability is used to disconnect a member from the multicast call;
- *Join call* (6.5): This capability is used to join (rejoin) a member of the multicast group to the multicast call;
- *Multicast call termination* (6.6): This capability is used to terminate the multicast call in its entirety;
- *Multicast status* (6.7): This capability is used to obtain the multicast group and call status information.

The following clauses provide details of the multicast service capabilities.

6.1 Multicast Group Creation and Membership Control

A multicast group defines a set of members who participate in the multicast service with other members of the group. The purpose of defining the multicast group as an independent entity is to facilitate those functions that deal with an entire group; for example, addressing and administration.

6.1.1 Multicast Group Creation

A multicast group is created and modified by a member (or third party) designated as the multicast group controller.

The multicast group may be created and modified by static administrative means or by using on-line procedures.

When the multicast group is created and modified by static administrative means, the party responsible for the multicast group requests the Administration to create or modify a group. An initial list of members may be indicated to the Administration.

The multicast group may also be created and modified using the on-line procedures. The group controller is authorized to create, modify and destroy the multicast group using on-line procedures (Figure 10 a)). The on-line procedures may be provided by an extension of the standard CCITT network management protocols.

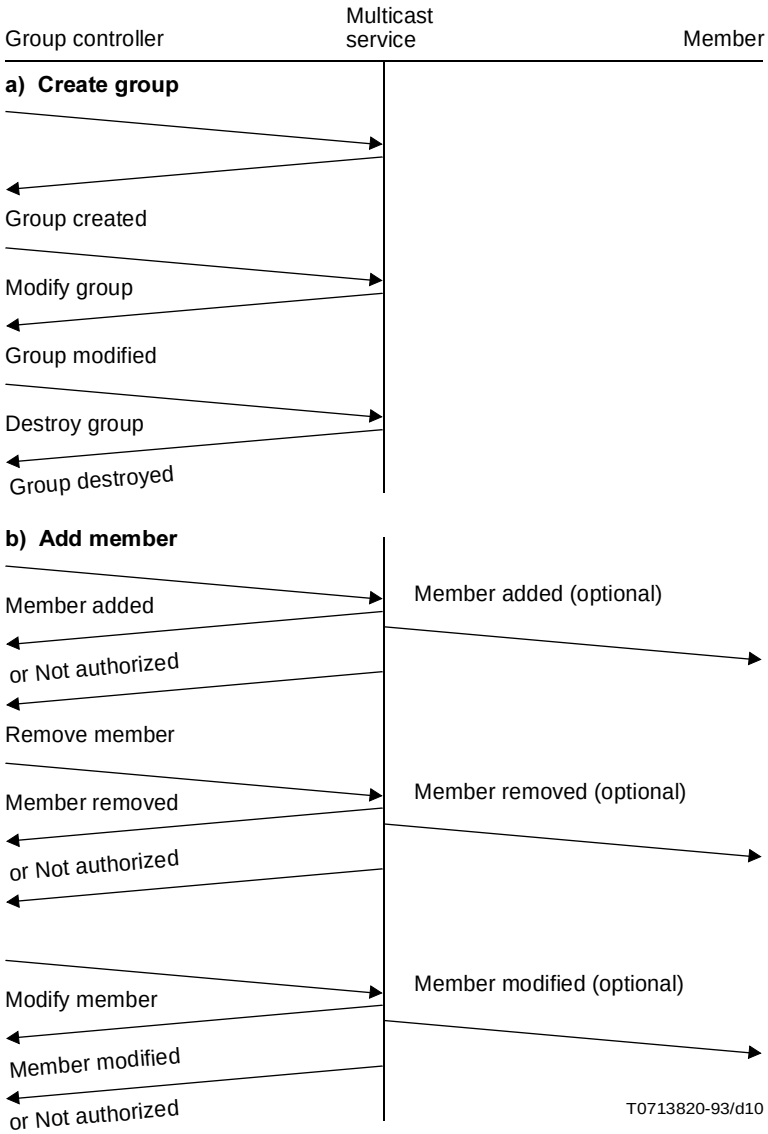


FIGURE 10/X.6

Group creation and membership control

The following attributes of the multicast group may be network-dependent:

1) which member(s) (or third party(ies) associated with the call or group) is authorized to be the multicast group controller;

2) which group member(s) (or third party(ies) associated with the call or group) has one or more of the multicast call capabilities (6.2.3);

3) which multicast call attributes (6.2.2) are common to the multicast group (e.g. all calls are one-way). Some of these may be changeable on a per-call basis depending on the multicast group or the network.

6.1.2 Multicast Group Identification

Once a multicast group is created, it is assigned a unique identifier, called the Group Identifier (ID).

The Group ID may be one of the following:

1) a single network address;

2) the network address of the server and some other identifier assigned by the server;

3) a closed user group interlock code;

NOTE – This is unique within an X.25 network;

4) an international closed user group interlock code;

NOTE – This is unique across X.25 networks;

5) any other identifier.

The Group ID is unique within a network, and may be unique within a larger context as well (see item 4 above). It may be combined with the network address to provide a globally unique Group ID.

6.1.3 Multicast Group Membership Control

The Multicast Group Membership Control capability is used to add and remove members from the multicast group. The multicast group controller is authorized to add (or remove) members from a multicast group.

This Group Membership Control may be provided by static administrative means or by using on-line procedures.

When static administrative means are used, the party responsible for the multicast group requests the Administration to add (or remove) the member(s) from the multicast group.

When the on-line capability is used, the multicast group controller may add (or remove) members from the multicast group using on-line procedures [Figure 10 b)]. The on-line procedures may be provided by an extension of the standard CCITT network management protocols.

The affected members may be informed when they are added (or removed) from the group.

NOTE – This capability does not apply to open groups.

6.2 Multicast call

The multicast call capability establishes the relationship between the members of a multicast group for the purpose of transferring data (Figure 11).

The multicast call may be established by static administrative means or by using dynamic on-line procedures (described in 6.2.4).

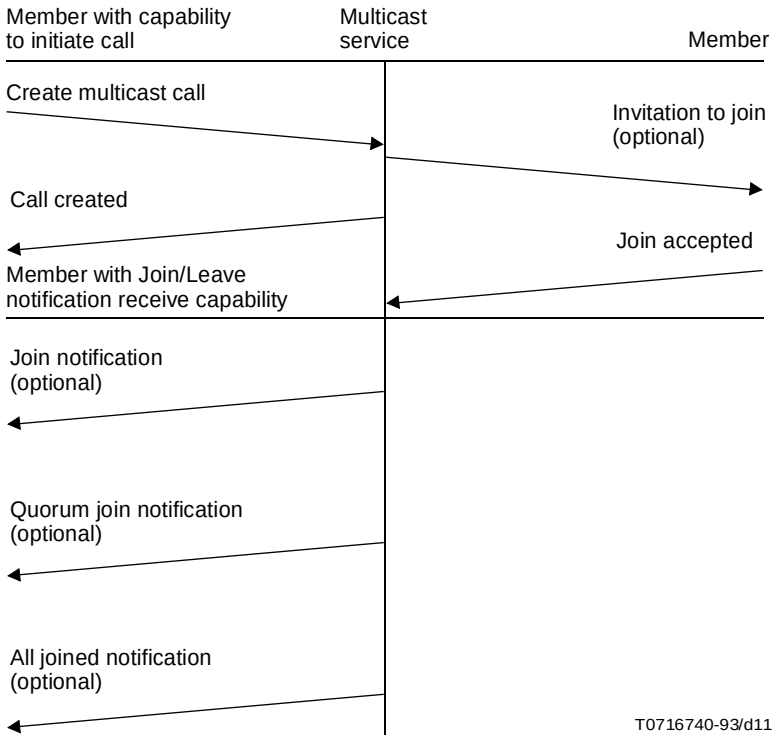


FIGURE 11/X.6

Multicast call establishment

6.2.1 Multicast call identification

A multicast call is identified by a unique identifier, called the Call Identifier (ID). The Call ID is unique within a multicast group.

The Call ID may be used, for example, by a member to rejoin a multicast call after disconnecting from it.

The Call ID may be combined with the Group ID to provide a globally unique Call ID.

The Call ID is assigned by the multicast service. The Call ID may be assigned *a priori* and made known to the members prior to joining the multicast call or it may be assigned in conjunction with the multicast call establishment.

6.2.2 Multicast call attributes

A multicast call may be described by the following attributes. Some attributes may be common for the multicast group and default values may apply (6.1.1).

Group ID: Identifies the multicast group.

Call ID: Identifies the multicast call for purposes such as using multiple multicast calls per group or allowing a member to join a call already in progress.

Exclusion/inclusion: Specifies whether members of the multicast group may be excluded (or included) from the multicast call.

NOTE – The exclusion or inclusion in a multicast call could be expressed using a list of addresses or as a rule, in the same way that a rule is used in specifying a multicast group.

Join origination selection: Specifies whether the service should send the invitations to join the other members (Figure 11) or whether other members join the call by sending a join request to the service [Figure 14 a)]. Some group members may only be allowed to join by sending a join request (for example, dial-in members or members of an open group).

Quorum: Specifies the minimum number of members needed for certain functions (e.g. join notifications). The action of the service when quorum is not met (e.g. suspend call, terminate call) is service-specific.

Data flow: Identifies the direction of data flow for the multicast call. The choices are: one-way, two-way, or *n*-way.

Connect priority: Specifies the priority of making this call.

Retain priority: Specifies the priority for keeping this call.

Transfer priority: Specifies the priority for data transfer within this call.

NOTE – The above three attributes dealing with priority align with the requirements for priority as given in Recommendation X.213. These are only useful when compared against priorities of other point-to-point and multicast calls. Each of the priority attributes can take on a maximum of 15 levels. The CCITT-specified DTE priority facility could be used to signal these attributes.

Aggregate timeout value(s): Specifies timeouts which apply where aggregate notifications (e.g. a quorum has joined call) are to occur.

Active group integrity: Specifies whether active group integrity applies to this call. If active group integrity applies, at least a quorum of participants must be joined to this call before any data transfer can occur. If the number of participants joined to the call drops below a quorum, the service will either terminate the call or enforce a cessation of data transfer until a quorum is again achieved.

NOTE – A variation on active group integrity may use "key member(s)" rather than a "quorum" of members, such that without these key member(s), the call will either be terminated or data transfer will cease.

Source identification: Specifies whether the source of data is indicated to the receivers of that data. The choices are: source is indicated, source is not indicated.

Other attributes that apply during the data transfer phase are described in 6.3.

6.2.3 Multicast member capabilities

Call participants or group members may have one or more capabilities that allow them to perform certain functions as part of managing or participating in multicast data transmission. Capabilities are assigned to group members as potential capabilities. When a group member participates in a call, the capabilities may be realized at that time.

Identification of addresses for some capabilities may be required as part of call establishment, depending on the attributes of the call.

The following call capabilities are included in the multicast service:

Initiate: This capability allows for the initiation of multicast calls.

Send: This capability allows a participant to act as a sender in a one-way call or a sender/receiver in a two-way call.

Receive: This capability allows a participant to act as a receiver in one-way calls, or as a receiver/sender in two-way calls.

Join/Leave notification receive: This capability allows its holder to receive join notifications ("a participant has joined a call"), quorum join notifications ("a quorum of participants has joined the call" or "this call no longer has a quorum"), all-joined notifications ("all members invited to join this call have joined"), and leave notifications ("a member has left the call" or "all members have left the call").

Join permission: This capability allows its holder to confirm or deny a request to join a call in progress by a potential participant.

NOTE – It would be inappropriate for multiple members to have this capability without some additional mechanisms for managing the potential conflicts.

Invite: This capability allows its holder to invite a potential participant to join a call.

Exclude: This capability allows its holder to exclude a member from a call in progress.

Control messages: This capability allows its holder to receive other miscellaneous control messages.

Terminate: This capability allows its holder to terminate a call in progress.

6.2.4 Multicast call establishment

The multicast call may be established by static administrative means or by using dynamic on-line procedures.

The static administrative means may be similar to those utilized for creating point-to-point permanent virtual circuits.

The dynamic on-line procedures are described below.

The member authorized to initiate the multicast call (member having initiate capability) issues a create multicast call request to the service (Figure 11).

Depending on the join origination selection attribute (6.2.2), the service may generate multiple invitation to join requests to the other members of the group. Each other member responds to the invitation to join with a join accepted or join not accepted response.

When the join origination is not issues by the service, a member may join the multicast call by sending a join request to the service [Figure 14 a)]. The service responds with a join confirmed or joined denied.

The service may inform the members with Join/Leave notification receive capability when the member(s) join by issuing a join notification depending on the Join/Leave notification attribute.

The service issues a call created response to the call initiator after a specified number of members (a quorum) have joined or a timeout occurs.

6.3 Data transfer

The multicast call enters the data transfer phase (Figure 12) when the call created is sent by the service. When the data sender is other than the call initiator, the data transfer phase is entered when that member joins the multicast call.

When static administrative means are used to establish the multicast call, the data transfer phase applies when the data sender interface is up.

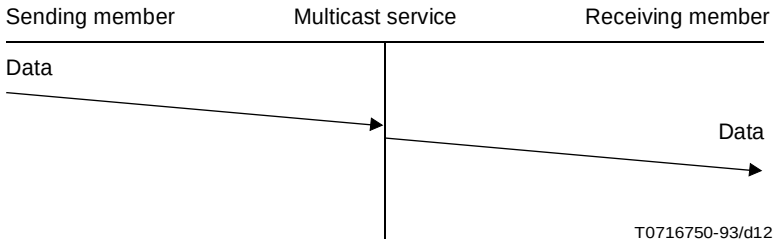


FIGURE 12/X.6

Data transfer phase

6.3.1 Data transfer attributes

The multicast data transfer phase may be defined by the following attributes.

NOTE – Other attributes are for further study. For example, the issue of segmenting an SDU (service data unit) into one or more PDUs (protocol data unit) should be addressed for two-way and *n*-way communications.

6.3.1.1 Data integrity

The data units received by a member shall not be corrupted. Loss of data between a sender and the server should be indicated to all participants in a call. Loss of data between the server and a receiver (for example, because of buffer overflows) should be handled as a local matter between the server and the affected receiver.

6.3.1.2 Synchronized data delivery

In synchronized delivery, all recipients of a synchronized data unit receive it within a certain defined time window. This is for further study.

6.3.1.3 Ordering

There are two types of ordering in multicast data transmission. In order of increasing restrictions, these are:

Local: PDUs from a particular sender will be transmitted by the service in the order they were received by the service.

Global: PDUs from multiple senders will be transmitted by the service in strict order, so a PDU received by the service at time t will be transmitted by the service before any PDU received by the service after time t.

Table 1 shows the applicability of ordering for one-way, two-way and *n*-way communications.

TABLE 1/X.6

Data ordering attribute

	Ordering	
Data Flow	Local	Global
One-way (single sender) One-way (multiple senders)	Mandatory Mandatory	Not applicable Optional
Two-way (single sender) Two-way (multiple senders)	Mandatory Mandatory	Not applicable Optional
N-way	Mandatory	Optional

6.3.1.4 Throughput

For a multicast call, data transfer takes place according to one of the following rules:

- at the pace of the slowest active receiver (the service is aware of this rate); the transmitter is flow controlled so as to prevent it from transmitting at a faster pace;
- at a minimum pace associated with the call where members who cannot keep up with this pace are not permitted to join the call;
- at a minimum pace associated with the call where members who cannot keep up with this pace are permitted to join the call but where data loss may occur.

6.3.1.5 Flow control

Specifies whether the service may or may not flow control the transmitter when a receiving member is flow controlled. When no flow control is used, data loss to the receiver is possible.

6.4 Leave Call

The Leave Call capability is used to disconnect (or exclude) member(s) from the multicast call. Once disconnected, the member ceases to participate in data transfer for that multicast call.

The Leave Call capability may be used by:

- a member that wants to leave the multicast call for any reason;
- a member with Exclude capability.

6.4.1 Member Initiated

A member may leave the multicast call by issuing a Leave request to the service [Figure 13 a)]. A member also leaves the multicast call when the member interface is declared out of order.

When the Leave notification capability is used (6.2.2), the service may notify the members having Join/Leave notification receive capability when the member leaves by issuing a Leave notification. A reason code (supplied by member, interface out of order, etc.) may be provided in the Leave notification.

6.4.2 Member Exclusion

A member with Exclude capability may request the service to exclude a member(s) from the multicast call be issuing an Exclude member request (Figure 13 b)). The member(s) may be excluded for example, when multicast communication to a sub-set of members is desired. The service is responsible for maintaining information on excluded members.

The service disconnects the specified member by issuing a Leave request to the member. A reason code (supplied by the member issuing the Exclude member request) may be provided in the Leave request.

When the Leave notification capability is used, the service may notify members with Join/Leave notification receive capability when the member leaves by issuing a Leave notification. A reason code (provided by the member issuing the Exclude member request) may be provided in the Leave notification.

6.5 Join Call

The Join Call capability is used to join (or rejoin) a member to the multicast call.

The Join Call capability may be used by:

- a member that wants to join (or rejoin) the multicast call;
- by a member with Invite capability.

6.5.1 Member Initiated

A member may join (or rejoin) the multicast call by using a Join request to the service [Figure 14a)] if the member has not been excluded from this call.

The server will notify members with Join/Leave notification receive capability when the member joins by issuing a Join notification. A reason code (member provided) may be provided in the Join notification.

If a member has the join permission capability, that member may inform the service if the member is allowed to join the multicast call or not by issuing a join confirm or join deny [Figure 14 a)].

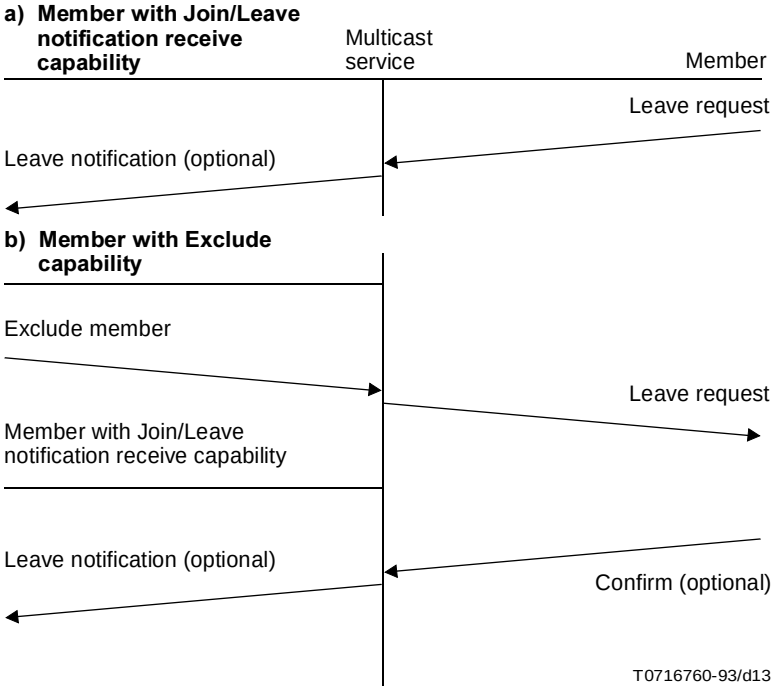


FIGURE 13/X.6

Leave call

6.5.2 Member Inclusion

A member with Invite capability may request the service to join a member to the multicast call by issuing an Include member request [Figure 14 b)].

The service attempts to join the specified member by issuing an Invitation to join to the member.

The service may notify members with Join/Leave notification receive capability when the member joins by issuing a Join notification. A reason code (provided by the member) may be provided in the Join notification.

6.6 Multicast Call Termination

The Multicast Call Termination capability is used to terminate the multicast call in its entirety.

The termination procedure may be initiated by a member with Terminate capability or the multicast service.

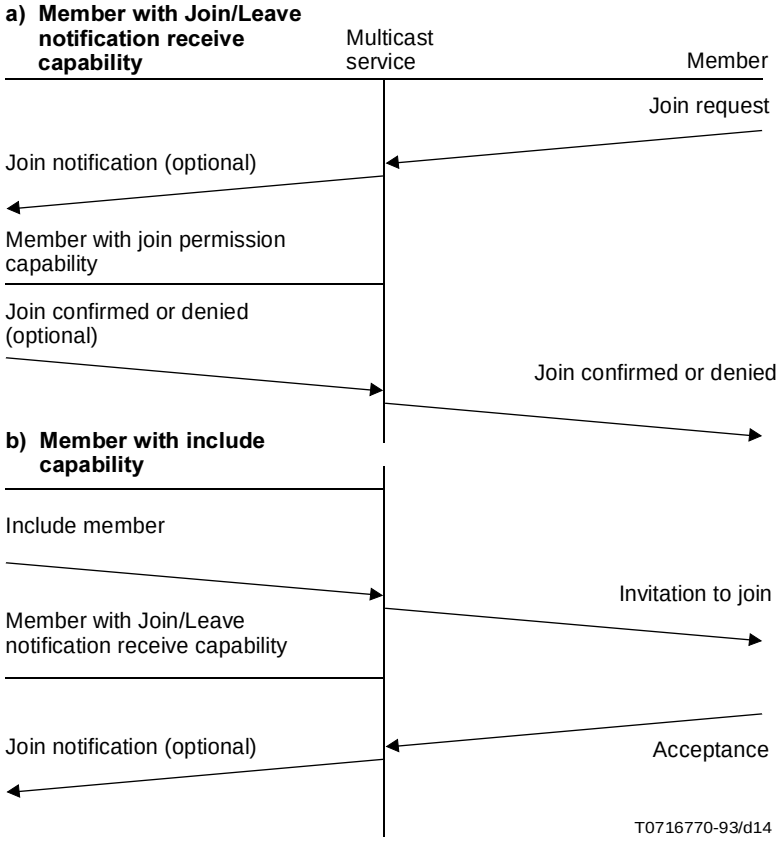


FIGURE 14/X.6

Join call

6.6.1 Member Initiated

A member with Terminate capability may terminate the multicast call at any time by issuing a Terminate call request to the service [Figure 15 a)]. The service may confirm the request.

The service generates a Call terminated to each of the other members of the active group. A reason code (supplied by terminating member) may be provided in the Call terminated.

A Call terminated indication may be sent to the member requesting call termination after a specified number of members (a quorum) have been disconnected or a timeout occurs.

6.6.2 Service Initiated

The multicast service may be allowed to terminate the multicast call when the number of active group members drops below a specified number (a quorum) or for other service-specific reasons.

The termination follows the procedures described in 6.6.1, except for the Terminate call request [Figure 15 b)].

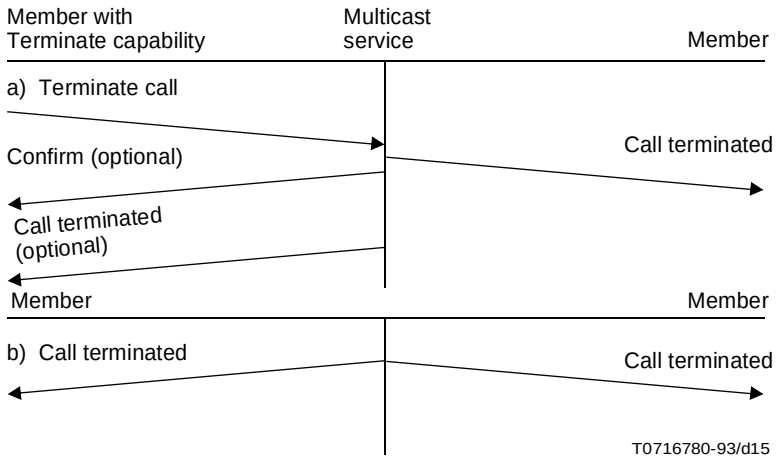


FIGURE 15/X.6

Multicast Call Termination

6.7 Multicast status

6.7.1 Group Status

The Group Status capability provides information about a multicast group. Group Status information may be obtained by static administrative means or using on-line procedures from a member (or third party) authorized to perform this request (Figure 16).

The following information may be provided. Other items are for further study.

- list of members of the multicast group;
- which member (or third party) is the group controller;
- the common and default attributes for the group;
- the multicast calls active in the group;
- which group member(s) has one or more of the multicast call capabilities (6.2.3) and what they are.

6.7.2 Call Status

The Call Status capability provides information about a multicast call. Call Status may be obtained by static administrative means using on-line procedures from a member (or third party) authorized to perform this request (Figure 16).

The following information may be provided. Other items are for further study.

- the active group;
- which group member(s) has one or more of the call capabilities (6.2.3) and what they are;
- the other call attributes (6.2.2).

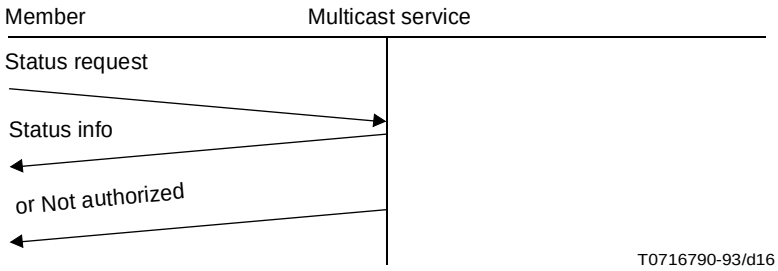


FIGURE 16/X.6

Status (Group/Call)

7 Data flow model

The operation of a multicast call is modelled in an abstract way by a set of pairs of queues (QxS and QSx) and the service. There is between the service and each call participant one pair of queues, that is, one queue for each direction (Figure 17). The terminology QxS implies a queue with a direction from a participant numbered x to the service (S). For a queue QSx, this is a queue with a direction from the service to the participant numbered x.

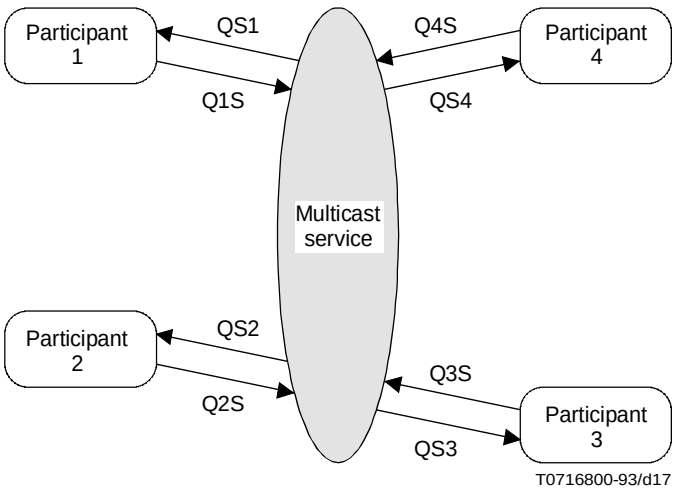


FIGURE 17/X.6

Abstract model of data transfer

This model is used to introduce the flow control feature and the functions performed by the service for each kind of operation. The ability of a call participant to add objects to a queue will be determined by the behaviour of the call participants removing objects from that queue, the behaviour of the service, and the states of the queues. Objects are entered and removed from the queues as a result of actions by call participants and the service.

A unique set of pairs of queues is considered to be available for each potential multicast call.

For example of this model, consider the operation of a multicast call in the data transfer phase. This phase begins when the first data object is placed in a QxS queue.

A sending participant (x) in a multicast call places data objects onto its queue QxS. The service removes data objects from the queue QxS and enters copies of each data object in each QSr queue (where r is each of the participants 1, 2, 3, ..., n except x).

The receiving participant (r) removes objects from its queue QSr. If there are multiple receiving participants, then they each remove their individual copies of the data object from their QSr queues.

Developers of protocol which implement the multicast service may want to use this model as a way of describing the operation of connection establishment, connection termination, data transfer, acknowledgement, flow control, and other aspects of multicast operation.

7.1 Queue configurations in different communication modes

Not all queues described in Figure 17 are used in all communication modes. Figure 18 shows this data flow model for one-way communication and Figure 19 shows two-way communication.

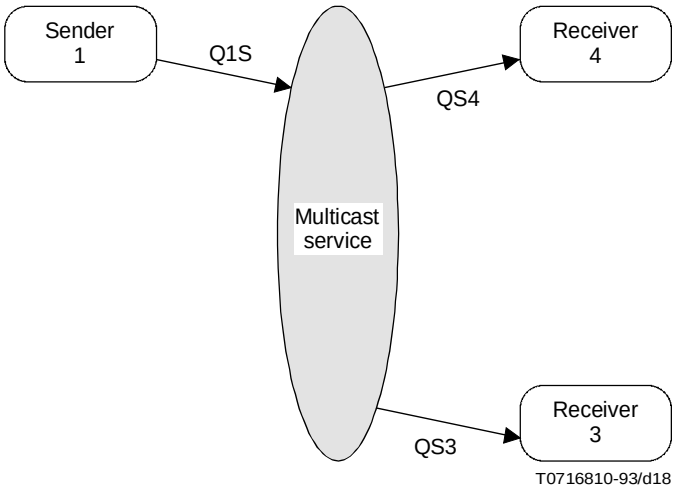


FIGURE 18/X.6

Model for data transfer – one-way communication

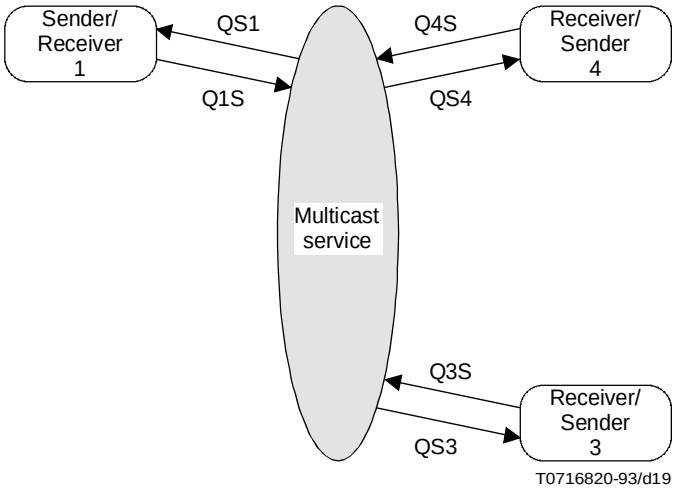


FIGURE 19/X.6

Model for data transfer – two-way communication

7.2 Data flow model and data transfer overview

In the three communications modes described in 5.1.1, 5.1.2 and 5.1.3 different rules are given. These rules are repeated in the following subclauses in the context of the data transfer model.

7.2.1 One-way

1) A receiver r has no queue QrS.

2) A sender x places a data object into QxS. The service removes it from QxS and places copies on each of the receiver queues QSr, r = 1, 2, ..., n.

3) Optionally, the service will also place copies on each of the sender queues (excluding original sender x) QSs, s = 1, 2, ..., m.

4) Optionally, the service will also place a copy on sender queue QSx.

7.2.2 Two-way

1) A sender/receiver x places a data object onto QxS. The service removes it from QxS and places copies on each of the sender/receiver queues QSr, r = 1, 2, ..., n.

2) A receiver/sender y places a data object onto QyS. The service removes it from QyS and places copies on each of the sender/receiver queues QSs, s = 1, 2, ..., m.

3) Optionally, the service will also place copies of the data object on the other sender/receiver queues (excluding original sender/receiver x) QSs, s = 1, 2, ..., m.

4) Optionally, the service will also place a copy on queue QSx.

5) Optionally, the receiver/sender y can indicate which of the sender/receiver queues QSs should receive the data object removed from receiver/sender queue QyS.

7.2.3 n-way

1) A participant s places a data object on queue QsS. The service removes it from the queue and places copies on all queues QSp, $p \neq s$.

2) Optionally, the service also places a copy on QSs.

Appendix I
(to Recommendation X.6)

Summary of group and call attributes

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

Tables I.1, I.2 and I.3 summarize the attributes of the multicast group and multicast call.

TABLE I.1/X.6

Multicast group attributes

Group Attribute Name	Value
Call Controller	List of call controllers
Group Status Request	List of members authorized to request status information
Initiators	List of members who may initiate calls
May Send	List of members who may be senders (or sender/receivers)
May Receive	List of members who may be receivers (or receiver/senders)
May Receive Join/Leave notification	List of members who may receive Join/Leave notification
May Invite	List of members who may invite others into calls
May Exclude	List of members who may exclude others from calls in progress
May Receive Control	List of members who may receive other control messages
May Terminate	List of members who may terminate calls in progress
Default quorum	Default quorum for calls (integer, or some other value, such as a percentage)
Default data flow	Default data flow for calls (1/2/n)
Default connect priority	Default priority for making connection (integer)
Default retain priority	Default priority for retaining connection (integer)
Default transfer priority	Default data transfer priority (integer)
Default aggregate timeouts	Default timeout values for calls (time)
Default active group integrity	Default active group integrity (True/False)
Default source identification	Default source identification (True/False)

TABLE I.2/X.6

Multicast call attributes

Call Attribute Name	Value
Quorum	Quorum for this call (integer, or some other value, such as a percentage)
Data flow direction	Data flow direction for this call (1/2/n)
Connect priority	Priority of making connection (integer)
Retain priority	Priority of retaining connection (integer)
Tansfer priority	Priority of data transfer (integer)
Aggregate timeouts	Timeouts for certain operations (time)
Active group integrity	Whether this group has active group integrity (True/False)
Source identification	Whether data units will include source address (True/False)
Have capability Send	List of members who may send in this call
Have capability Receive	List of members who may receive in this call
Have capability Join/Leave notification receive	List of members who will receive Join/Leave notifications
Have capability Invite	List of members who may invite others into call
Have capability Exclude	List of members who may exclude others from call in progress
Have capability Control	List of members who will receive other control messages
Have capability Terminate	List of membes who may terminate the call

TABLE I.3/X.6

Data transfer attributes

Data Transfer Attribute Name	Value
Data integrity	(Does not apply)
Ordering	Local or Global
Synchronized delivery	For further study
Throughput	At pace of slowest active receiver, at minimum pace with no loss; at minimum pace with possible loss
Flow control	Server may/may not flow control

Appendix II

(to Recommendation X.6)

Mapping Applications into Multicast Services

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

This appendix provides examples of applications which may be appropriate for a multicast environment. These examples are provided to show how some of the options in this Recommendation can be used to satisfy specific application needs. The implementations described are given for example only.

II.1 News service

A news service provides continuous updates on current stories. There is a single feed of information and no feedback is allowed from the subscribers to the service.

This application could use one-way data transfer, with a single sender. A call is created and subscribers join and leave the call as they wish. The sender passes data into the call continuously.

In addition, the call could be set up with a quorum of 1, so that the sender does not send data out when there is no receiver.

II.2 Weather service

A weather service provides updates on weather conditions in various locations. These updates come from hundreds of automated sensors in different geographic locations which send out updates periodically.

This application could use one-way data transfer with many senders. Each sensor would be a sender. Because these are send-only devices, a one-way call is appropriate.

II.3 Information service with backup device

An information service might want to have a high reliability, such that if a service provider fails, a send provider should come on-line immediately. In this case, failure of a provider may occur for reasons external to the network interface. An example of this application is a transmitted Videotex system.

This application could use one-way data transfer with two senders. The senders would choose the option to have their packets sent to each other in addition to the receivers. Thus, the backup server can detect failure of the primary server when transmissions from the primary server stop.

II.4 Examination

A computerized examination system would ask multiple people the same questions and then receive answers from each of the people taking the examination. An example of this application is the college entrance examination.

This application could use two-way data transfer. The examiner would be a sender/receiver and the students/examinees (receivers/senders) would transmit their answers back only to the examiner.

II.5 Name service

A name service has a network of data base servers which anyone can query to look up names. There are multiple servers and multiple simultaneous queries. An example of this is the Internet Domain Name Service.

This application could use two-way data transfer. The data base servers would be receiver/senders. Someone wishing to use the service would connect as one of the (possibly many) sender/receivers in the call, send their query, and receive an answer directed back to them. They would then leave the call.

II.6 Distributed data base

A distributed data base may have multiple partitions across multiple systems in multiple locations. An example of this application is a city's multiple hospital records data base.

This application could use *n*-way data transfer. The data base systems would all participate as peers in a call, with any updates passed between all members.

II.7 Time service

A distributed network time protocol can be used by systems to maintain extremely accurate clocks, even over networks with high delays. Time servers are organized into a hierarchy of layers (called "strata") which communicate to converge on an approximation of the current time. An example of this application is the Internet Network Time Protocol.

This application could use two-way data transfer, with members higher in the hierarchy acting as sender/receivers to members lower in the hierarchy acting as receiver/senders. Multiple calls could be used. Two options of two-way transfer would be useful. By distributing updates to other services at the same level (i.e. sender/receiver packets go to all other sender/receivers as well), servers can do sanity checking and verification. By returning updates (i.e. sender/receiver packet sent back to itself), the sender/receiver can help approximate round-trip delay between it and the time server.

II.8 Interpersonal on-line conferencing

An on-line conference has multiple participants all sending messages which all other members receive. Sometimes, a subset of the participants may wish to break off a brief separate conference with each other. An application of this is the standards development process.

This application can use *n*-way data transfer. Each participant in the conference would see all messages sent by all other participants. Some implementations of the user interface may wish a message sent to be returned to the same sender, as well. The subset functionality would either require a new call to be created or could use the sub-call service for faster set up.

II.9 Lottery service

A lottery system requires periodic updating of point-of-sale lottery terminals with new information and software. Normal use (i.e. buying tickets) is via point-to-point transfer, but the periodic information transfers are of a multicast nature.

The application could use terminals connected to a PAD (packet assembly/disassembly) operating with one-way data transfer, where the PAD provides the multicast service.

II.10 Product announcements

A manufacturer might wish to distribute product announcements via facsimile. This involves sending the same image to multiple recipients. The facsimile protocol is inherently two-way, because negotiation between two fax machines occurs before each image transmission.

The application could use fax machines connected to a FAX PAD which provides the multicast service. Two-way data transfer is required, as well as a multi-party negotiation support for fax options between multiple receivers and a single sender.

II.11 Audio/Graphic Conferencing

Audio/Graphic Conferencing involves the use of Audio/Graphic terminals and Multipoint Control Units. Point-to-point connections are used to connect the Audio/Graphic terminals to the Multipoint Control Units, and for connecting the Multipoint Control Units to each other.

The application could be supported by a combination of *n*-way calls to connect Multipoint Control Units (including the sub-call capability) and a two-way call to connect each Multipoint Control Unit with the Audio/Graphic Terminals that it serves.