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SERIES X: DATA NETWORKS AND OPEN SYSTEM COMMUNICATIONS

OSI networking and system aspects – Networking

Information technology – Relayed multicast protocol: Framework

ITU-T Recommendation X.603

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INTERNATIONAL STANDARD ISO/IEC 16512-1
ITU-T RECOMMENDATION X.603

Information technology – Relayed multicast protocol: Framework

Summary

The Relayed Multicast Protocol (RMCP) is an application-layer protocol for providing end-to-end multicast services over an IP-network environment. This Recommendation | International Standard specifies basic concepts of a relayed multicast scheme, data delivery models, service scenarios, required protocol functions for protocol operation, and basic message structures. This framework can be used to specify detailed relayed multicast protocols for various application requirements.

Source

ITU-T Recommendation X.603 was approved on 29 April 2004 by ITU-T Study Group 17 (2001-2004) under the ITU-T Recommendation A.8 procedure. An identical text is also published as ISO/IEC 16512-1.

Keywords

End-to-end multicast service, Framework, Multicast Agent, Relayed multicast, Session Manager.

FOREWORD

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CONTENTS

Introduction

This Recommendation | International Standard specifies the Relayed Multicast Protocol (RMCP) used for realizing relayed multicast. Relayed multicast, also known as overlay multicast or application-layer multicast, is a data-delivery scheme for group communications applications over unicast. RMCP employs intermediate Multicast Agents for relaying application data from one or more senders to many receivers.

The design of RMCP has been motivated from the following observations:

In the marketplaces, diverse group applications and services have been provisioned commercially all over the world. Their examples include Internet TV, remote education, real-time streaming media applications, live broadcasting of special events such as the Victoria Show, stock-tickers, and so on.

At present, most of the group applications mentioned above use a replicated IP unicast method to realize multicast services. As a result, those applications have problems about degradation of service quality due to the limitation in the number of simultaneous service users. In the business model that means less revenue or profit.

IP multicast has been known as an effective transport technology for providing multicast services. Nevertheless, the IP multicast has not been deployed widely over the Internet due to several reasons, including the following:

- high deployment cost along with an uncertain Return-on-Investment model;
- IP multicast alone cannot support all kinds of group applications.

Network services which offer, for example, group file transfer or network games, need a reliable multicast transport mechanism. However, even current reliable multicast transport mechanisms still have unresolved problems including that of scalability, flow control, congestion control, etc. Until an appropriate multicast transport mechanism is laid down, group communications applications requiring reliable data transfer will continue to depend on the server-based replicated unicast method.

Although IP multicast has not deployed globally, a lot of local networks have already been equipped with IP multicast transport. For example, Ethernet-based LANs and private networks such as corporate and campus networks substantially provide the multicast transport capability within their local subnet or administrative domains.

Recognizing these observations, there is a crucial need to develop an alternative multicast delivery scheme. RMCP is one of such schemes to realize multicast delivery over the current Internet. It makes good use of existing unicast, multicast and/or multicast tunnelling schemes. In addition, RMCP is designed as several separate forms to support well any kind of group service type. RMCP is expected to provide a substantial solution for group applications over the real-world Internet.

INTERNATIONAL STANDARD
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Information technology – Relayed multicast protocol: Framework

1 Scope

RMCP is a protocol which is used to realize a relayed multicast data transport scheme. Differently from the conventional IP multicast, RMCP can configure a relayed multicast path that multicast traffic flows by using intermediate end-hosts. RMCP can be applied to the current unicast based Internet where IP multicast has not been deployed completely without any modifications.

This Recommendation | International Standard addresses the basic concepts needed to specify RMCP for relayed multicast. It defines the related terminology and proposes a framework for the future development of RMCP. The framework covers network topology including network entities and the relationship between them, service scenarios, basic operations, and message encoding rules.

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 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

For the purposes of this Recommendation | International Standard, the following definitions apply:

3.1 **multicast**: A data delivery scheme where the same data unit is transmitted from a single source to multiple destinations in a single invocation of service.

3.2 **IP multicast**: Realizes a multicast scheme in the IP network with the help of multiple multicast-enabled IP routers.

3.3 **relayed multicast**: A multicast data delivery scheme within unicast environments.

3.4 **relayed multicast protocol (RMCP)**: A protocol to realize the relayed multicast scheme using end hosts.

3.5 **RMCP session**: A set of MAs which configures the data delivery path using RMCP.

3.6 **session ID (SID)**: Corresponds to group name and identifies RMCP session uniquely.

3.7 **multicast agent (MA)**: An intermediate node which relays group application data.

3.8 **sender multicast agent (SMA)**: An MA attached to a sender in the same system or local network.

3.9 **receiver multicast agent (RMA)**: An MA other than SMA.

3.10 session manager: An RMCP entity that is responsible for the management of session membership and session tree.

3.11 parent multicast agent (PMA): A next upstream MA in the RMCP data delivery path.

3.12 child multicast agent (CMA): A next downstream MA in the RMCP data delivery path.

3.13 simplex: Wherein only one sender is send only and all others are receive only.

3.14 N-plex: Wherein anyone can send something, and, if someone does so, all others may receive it.

4 Abbreviations

For the purposes of this Recommendation | International Standard, the following abbreviations apply:

CMA	Child Multicast Agent
CP	Contents Provider
ID	Identificator
IP	Internet Protocol
IPC	Inter-Process Communication
IPIP	IP in IP encapsulation
MA	Multicast Agent
PMA	Parent Multicast Agent
RMA	Receiver Multicast Agent
RMCP	Relayed Multicast Protocol
RMT	Reliable Multicast Transport
SCTP	Stream Control Transport Protocol
SID	Session ID
SM	Session Manager
SMA	Sender Multicast Agent
T/TCP	TCP extensions to Transactions
TCP	Transmission Control Protocol
TP	Transport Protocol
UDP	User Datagram Protocol

5 Framework of RMCP

5.1 Introduction

Relayed Multicast Protocol (RMCP) is an application-level control protocol. It constructs and manages a *relayed multicast network* to support Internet group application services over the current unicast-based Internet. After a series of RMCP control messages are exchanged, a *multicast data delivery path* is constructed by using multiple end hosts, such as even a personal desktop computer. Along the delivery path, real-time or reliable data transport channels are inter-connected between upstream and downstream MAs. Only after the data delivery path and data channel are established can group applications work as if they were in a native IP multicast network.

RMCP aims to support various kinds of Internet group applications. Table 1 categorizes the types of communications and the characteristics of data delivery.

Table 1 – Considerable Internet group application services

Characteristics / Type of communications	Real-time data	Reliable data
Simplex	Internet live TV, Internet live banner, etc.	Stock-ticker, file dissemination, software live update, etc.
N-plex	Videoconference, inter-domain multicast proxy, etc.	Distributed virtual environment, network game, data mirroring and caching, etc.

5.2 Basic concept of RMCP

Each RMCP session configures relayed multicast data delivery model with the following entities as shown in Figure 1:

a) One session manager;

b) SMA per sender application;

c) One or more RMAs;

d) Group applications sending or receiving group data.

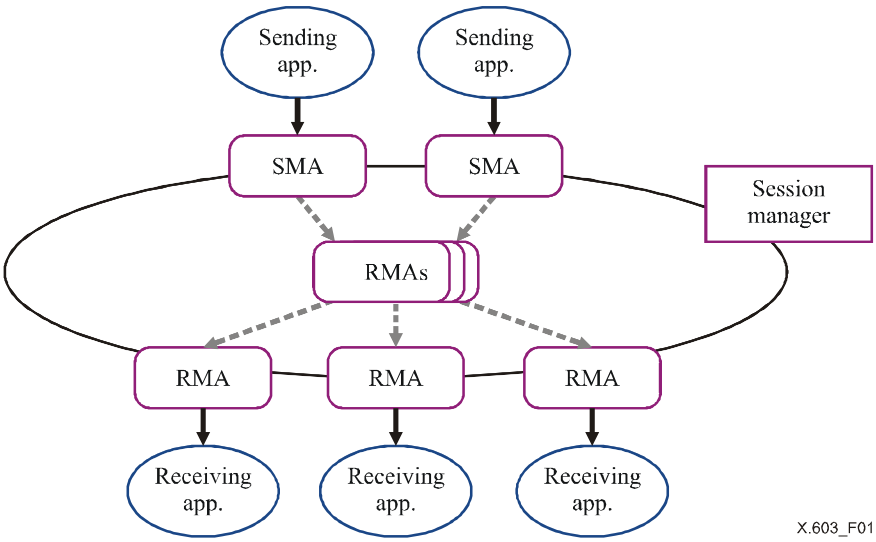

Figure 1 – RMCP entities

The SM (session manager) is just involved in session configuration and maintenance. A single SM can handle one or multiple sessions simultaneously. An SM can be implemented within one of other RMCP session entities or not. An SM can provide the following functionalities:

a) Session initialization;

b) Session release;

c) Session membership management;

d) Session status monitoring.

The *MA (Multicast Agent)*, which covers both SMA and RMA, constructs a relayed multicast delivery path and forwards data along the constructed path from PMA to CMAs and receivers if any. An MA consists of a *RMCP control module* and a *data transport module*. The main function of the former is to establish a relayed data delivery path and that of the latter to set up a data channel along the path constructed by the control module and a relay data through the channel. Figure 2 shows protocol stacks for each module inside of an MA.

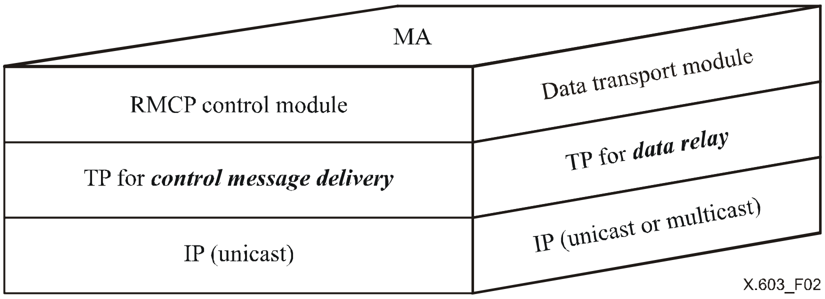

Figure 2 – Inside of Multicast Agent (MA)

The *RMCP control module* exchanges control messages with other RMCP entities. It performs as follows:

a) Session join;

b) Session leave;

c) Session maintenance;

d) Session status reporting.

The message flows of a *RMCP control module* are shown in Figure 3. As shown in the figure, an MA can be implemented in the same system with an application or not. To deliver the control messages, any kind of reliable unicast transport protocols will be selected. An application and MA can be located in a same system or in a local network such as Ethernet-LAN.

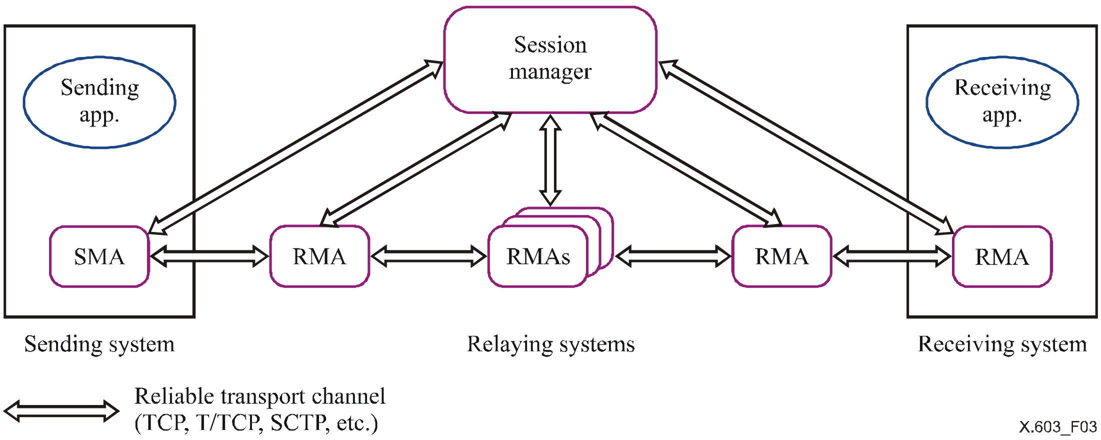

Figure 3 – RMCP control model

The *data transport module* relays data along the relayed multicast data delivery path constructed by the control module as shown in Figure 4. The relayed multicast delivery path consists of one or more senders, an SMA per sender, one or more RMAs and receivers. Any kind of transport protocols can be chosen to set up the data delivery channel.

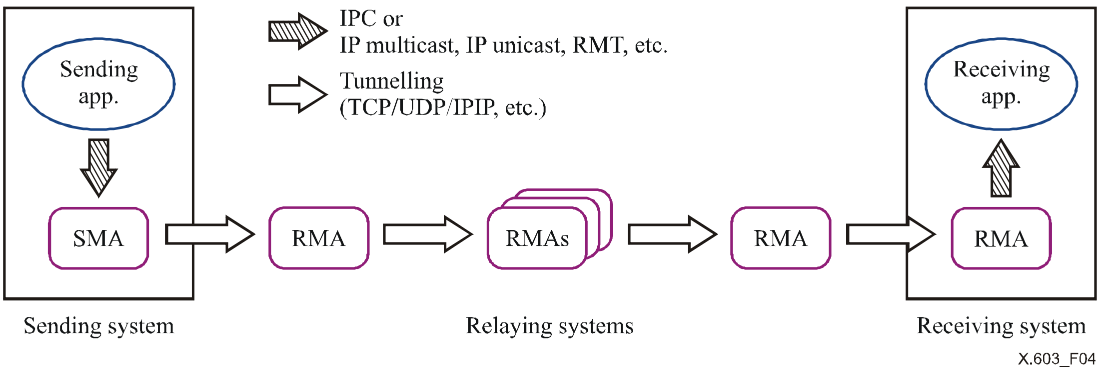

Figure 4 – RMCP data transport model

According to the way of relaying data, an MA can act as an SMA or an RMA. While an RMA receives data from a PMA and then forwards to CMAs and receivers if any, an SMA receives data from the original data sender directly and then forwards the data to CMAs only. The number of SMAs depends on the number of original data senders while the number of RMAs does not.

5.3 RMCP data delivery models

5.3.1 Simplex delivery model for real-time services

Simplex real-time broadcasting services such as Internet live TV and software banner require a real-time data delivery path from one sender to multiple receivers. The most optimized data delivery path here would be a per-source relayed multicast tree where each receiver is connected to the sender along the shortest path. Along the path, a unidirectional real-time channel must be established. Figure 5 shows one of the possible relayed multicast trees configured by RMCP for simplex real-time applications.

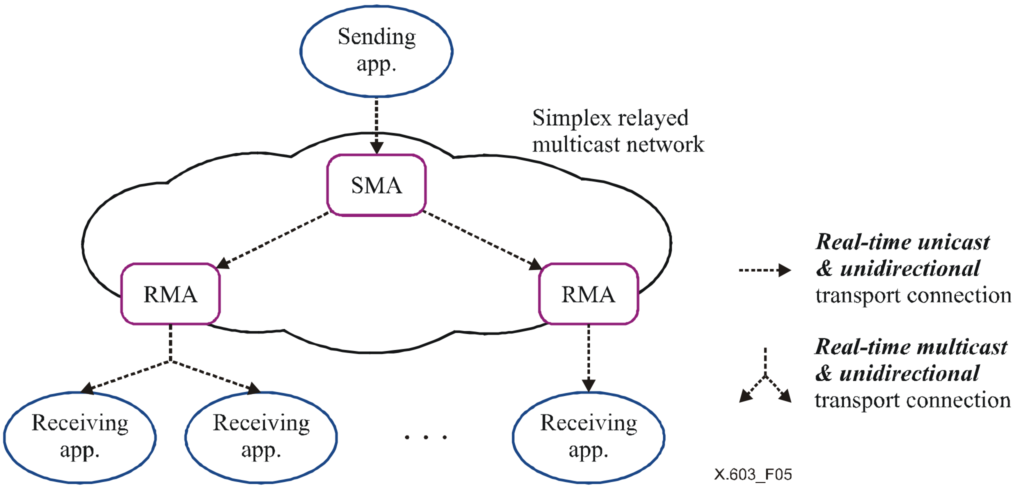

Figure 5 – Simplex real-time data delivery model

5.3.2 Simplex delivery model for reliable services

Simplex dissemination applications such as stock-ticker, file dissemination and software updater also require a reliable data delivery path from one sender to multiple receivers. The most optimized data delivery path here would also be a per-source relayed multicast tree. Along the path, a unidirectional reliable channel should be constructed to deliver data reliably. Figure 6 shows one of the possible relayed multicast trees configured by RMCP for simplex reliable applications.

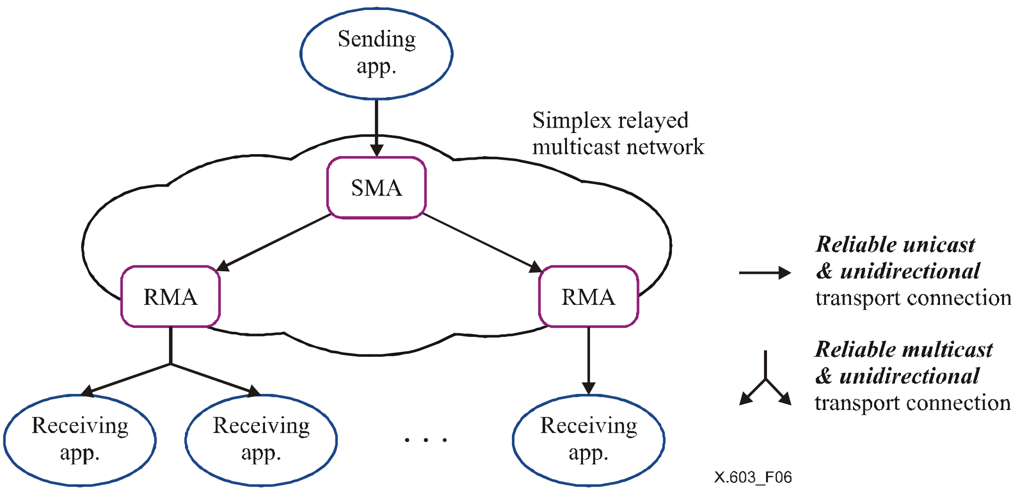

Figure 6 – Simplex reliable data delivery model

5.3.3 N-plex delivery model for real-time services

N-plex real-time interactive applications such as videoconference and inter-domain multicast proxy require a robust and optimized data delivery path from multiple senders to multiple receivers at the same time. Per-group shared relayed multicast tree is more reasonable in the N-plex case than per-source multicast tree. Along the path, bidirectional real-time channel should be constructed. Figure 7 shows one of the possible relayed multicast trees configured by RMCP for N-plex real-time group communications applications.

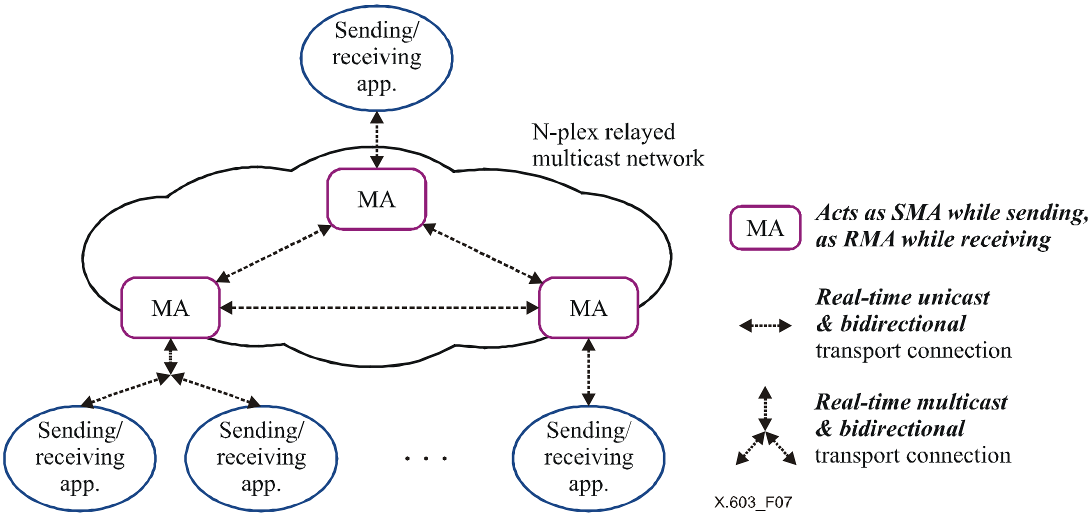

Figure 7 – N-plex real-time data delivery model

5.3.4 N-plex delivery model for reliable services

N-plex distributed applications such as distributed virtual environment, network games, data mirroring and caching need to deliver data reliably from multiple senders to multiple receivers.

Similar to the N-plex real-time case, per-group shared relayed multicast tree is one of the most optimized data delivery path schemes. However, bidirectional reliable channel is required in contrast to the N-plex real-time case. Figure 8 shows a possible relayed multicast tree configured by RMCP for N-plex reliable group applications.

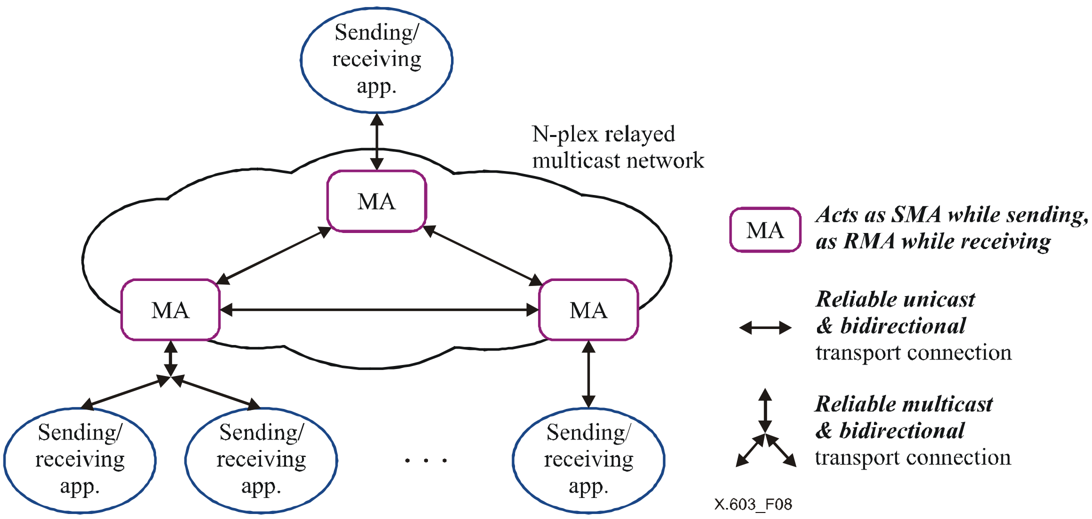

Figure 8 – N-plex reliable data delivery model

6 RMCP service scenario

This clause explains the role of RMCP inside group multicast services. It has chosen *Internet Live TV* service, which could be an example of group communications service supported by RMCP.

Assume that the *Internet Live TV* service illustrated here consists of the contents provider, web server, media server, and RMCP clients as shown in Figure 9. In this scenario, a service user gets information about *Internet Live TV* service schedules served by the contents provider via a web server and starts *Internet Live TV* application which invokes the RMCP protocol entity (RMA) to receive broadcasting stream from the media server. The detailed descriptions of this service scenario follow.

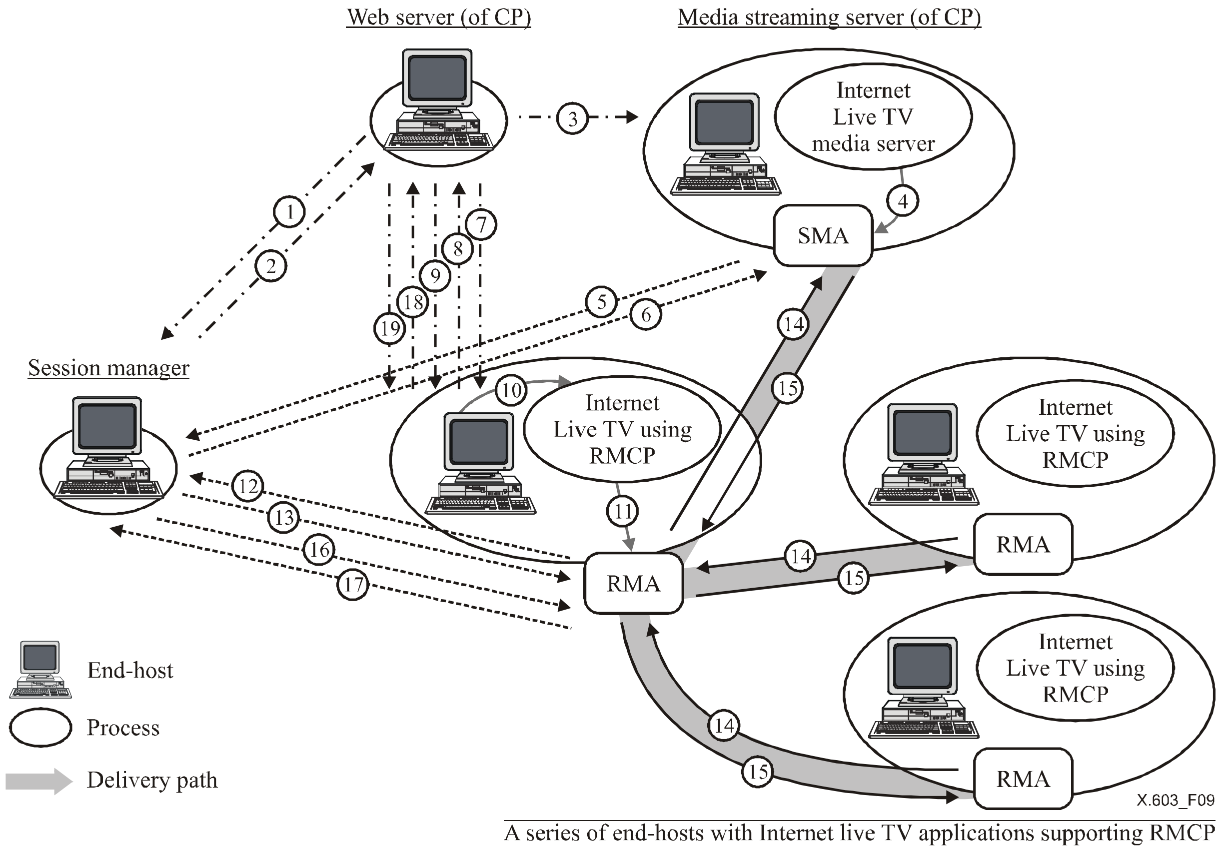

Figure 9 – Example scenario of Internet Live TV service using RMCP

In sequences 1 and 2 in Figure 9, a contents provider contacts the Session Manager. The contents provider asks the SM to initiate the RMCP service by offering information such as media characteristics, session name, group addresses and so on. As the response of success, the SM allocates SID for each session and sends SID to the CP. The contents provider announces via the web server for the *Internet Live TV* programme schedule and other additional information if needed such as name of the services, group address, media characteristics and so on.

A series of procedures to prepare *Internet Live TV* media server is described in sequences 3 to 6. According to the schedule announced before, the contents provider invokes Internet Live TV Media Server which follows by Media Server's invocation of SMA. SMA starts session joining procedure with SM.

Sequences 7 to 9 illustrate a prospective contents user's accessing sequence to the *Internet Live TV* service. Any prospective contents user gets information about the broadcasting schedule from the web server. To use the service, the service user logs onto the service page, and undergoes an authentication procedure. After successful user authentication, a series of session information necessary for the RMCP session join can be acquired from the web server.

Sequences 10 and 11 illustrate a series of service user's local calls to invoke RMA. After the user's invocation of the Internet live TV player application with the session information acquired from the contents provider, RMA is invoked.

Sequences 12 and 13 illustrate a series of RMA's session join sequence. Firstly, the RMA sends the join request to the SM. The SM examines whether the RMA is fully qualified to join the session. If it is acceptable, the SM responds to the RMA with available PMA list; otherwise, the SM rejects the join request, indicating reasons for the failure.

Sequences 14 to 17 illustrate a series of RMA's efforts to construct and manage a multicast data delivery path. After a successful join request, the RMA selects the best PMA among the PMA list with respect to network distance, data delivery channel cavity, and so on. RMA asks the selected PMA whether it can relay data. If it can, a relayed multicast data delivery path and a data channel between the RMA and PMA are established. After this stage the RMA completes its joining the session. After the data delivery path construction is finished, data can be delivered along the constructed relayed paths from media server to one or more end applications, e.g., media player. After multicast data flows along the data delivery path, the SM can collect each MA's status with the purpose of monitoring the whole session status. The MA should reply according to the SM's query. To maintain a stable data delivery path, RMCP should be equipped with an error recovery mechanism for unexpected errors. The detailed mechanism is out of the scope of this Recommendation | International Standard.

To provide a contents user's leave from the service, the contents user's leaving the RMCP session is illustrated in sequences 18 to 19. When the service user wants to stop receiving *Internet Live TV* stream, it can leave at any time. The related RMA can finish its role according to whether or not it acts as PMA. If the RMA has no CMA, it can leave the RMCP session promptly. Otherwise, it tells its CMAs implicitly or explicitly of its leaving the session; the CMAs then need to find a new PMA as soon as possible. Finally, the contents user logs out from the web server.

The scope of RMCP covers the *enrolment phase* to the *data transfer phase* defined in ITU-T Rec. X.601.

7 RMCP functions

7.1 Session initialization

The SM allocates a SID for each new session. The SID corresponds to the group name with which SM identifies the session. The SM has the information about session to construct. The information includes characteristics of media, session, authentication and so on. SM waits for subscription request from the MA.

7.2 Session join

Each MA contacts the Session Manager by sending a subscription request. The location of the SM has been already notified to each MA. The SM must respond to the subscription request to indicate whether the requester is qualified to join the session. If the MA's subscription request is successful, it can get a list of PMAs from the SM. That means SM does not specify the best parent to the MA. The MA instead chooses the best parent for itself. It may select the nearest and most resourceful MA as PMA. Otherwise, when the response from the SM indicates any rejection or there is no response from the SM, the MA cannot join the session.

The RMA which gets the subscription allowance can send a relay request to its PMA and then waits for the response from the PMA. SMA does not send a relay request to its PMA, because it does not have any PMA. The relay request should include enough information such as IP address and port number of the MA data channel and preferred data channel type for the connection between them. If the PMA allows the request, it informs the requester of relay allowance. Then it starts to establish a data channel between itself and the requester by invoking its data transport module as the preferred type of data channel indicated in the relay request.

If the PMA does not allow the request, then it sends relay denial notification and the requester searches another PMA or stops joining to the session.

Only after succeeding in the relaying procedure can the MA begin to receive application data from the sender by invoking its data transport module.

7.3 Session leave

When an MA wants to leave the session, it gives notice to its PMA and CMAs.

7.4 Session release

A RMCP session can be released as needed.

7.5 Session maintenance

After a data channel has been established successfully, the relay request and its response will be exchanged between the two MAs periodically. This is done for the detection of failed MAs and for data delivery path maintenance. If a PMA notices that one of the CMAs has failed, the PMA will stop transmission of data to the concerned CMA.

The original configuration of the relayed multicast tree can be changed by failure of some MAs or channel. A new joiner or a new leaver of the data delivery path can also change the topology. This change can cause partition or path loop in the data delivery path. Therefore, it is necessary for each MA to maintain the data delivery path.

The maintenance function of relayed multicast tree consists of the following:

a) Loop detection and avoidance;

b) Partitioning detection and recovering;

c) Parent switching.

7.6 Session monitoring

Session monitoring is used for SM to monitor session status such as membership dynamics and QoS perceived by MAs. The status report request and its response are exchanged between MA and SM. The SM can ask a specific MA to report its status and the concerned MA should report the result to the SM after dealing with jobs asked.

The RMCP session monitoring function consists of the following:

a) Reporting the status of the data channel: data throughput, etc.;

b) RMCP membership gathering;

c) RMCP topology information gathering.

8 Message structure

8.1 Basic message structure

RMCP control messages are used to initialize or manage the relayed multicast data delivery path. They are encapsulated in transport segments, as shown in Figure 10.

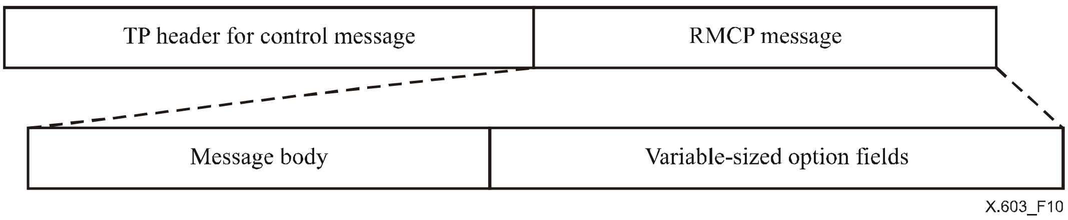

Figure 10 – Encapsulation of the RMCP control messages

Data from the original data sender is encapsulated as shown in Figure 11.

TP header for data relay	Original data from sender

Figure 11 – Encapsulation of original data

8.2 Option format

Each RMCP control message can include an option field if needed. Figure 12 shows the RMCP option fields, which consist of variable-sized option and padding fields.

Options (variable length)	Padding

Figure 12 – RMCP option fields

Figure 13 shows each RMCP option format. The option type is used to describe which option is used, and the length for the size of option. Option data is positioned in the value field. Because the type field is 1 byte long, the combination of unique option type can reach 256 cases. In the 256 cases, type values of all ZEROs and all ONEs are reserved for future use.

0	8	16 24 31
Type (8)	Length (8)	Value (variable-size)

Figure 13 – Each RMCP option format

One or more options can be located in one RMCP options field. When multiple options are used, options should be aligned as shown in Figure 14.

Option type 1	Option type 2	Option type 1	Padding

Figure 14 – Multiple RMCP options in a message

8.2.1 Option types and values

Each RMCP control message can define any kind of option at its disposal. Currently, only two option types have been defined in the framework; any other specific options are out of the scope of this Recommendation | International Standard.

8.2.1.1 Padding option

The padding option is specially devised to align a 32-bit message width as shown in Figure 15.

0 7
Type = zero

Figure 15 – RMCP padding option

8.2.1.2 Option extension

If the option type field needs to be extended to hold further option types, the extension option can be used to extend current option types. Figure 16 shows the extension option.

0	8	16	24 31
Type = 255 (8)	Ext. type (8)	Length (8)	Value (variable)

Figure 16 – RMCP extension option

BIBLIOGRAPHY

The following IETF RFCs are useful to understand this Recommendation | International Standard:

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