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Information technology — Relayed multicast protocol: Specification for simplex group applications

Technologies de l'information — Protocole de multidiffusion relayé: Spécifications pour applications de groupe unidirectionnel

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Foreword

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ISO/IEC 16512-2 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.603.1 (02/2007).

ISO/IEC 16512 consists of the following parts, under the general title *Information technology — Relayed multicast protocol*:

- *Part 1: Framework*
- *Part 2: Specification for simplex group applications*
- *Part 3: Specification for N-plex group applications*

Introduction

Relayed MultiCast Protocol Part 2 (RMCP-2) is an application-layer relayed multicast protocol for simplex group applications. RMCP-2 can construct an optimized and robust one-to-many relayed multicast delivery path over a unicast network with the help of RMCP entities defined by ITU-T Rec. X.603 | ISO/IEC 16512-1.

An RMCP-2 session consists of one SM and one or more MAs; SM initiates and terminates RMCP-2 session and manages RMCP-2 session and participated MAs; MA configures an RMCP-2 tree to deliver group data by exchanging a series of RMCP-2 control messages.

Along the relayed multicast delivery path, several types of data delivery channels can be constructed according to the requirement of application services.

INTERNATIONAL STANDARD
ITU-T RECOMMENDATION

Information technology – Relayed multicast protocol: Specification for simplex group applications

1 Scope

This Recommendation | International Standard describes the Relayed MultiCast Protocol (RMCP) Part 2, an application-layer protocol, which constructs multicast tree for data delivery from a sender to multiple receivers over Internet where IP multicast is not fully deployed. The specified relayed multicast protocol consists of multicast agent and session manager. This Recommendation | International Standard specifies a series of functions and procedures of multicast agent to construct one-to-many relayed data path and to relay simplex data. It also specifies the operations of session manager to manage multicast sessions. This protocol can be used for applications that require one-to-many data delivery services, such as multimedia streaming service, file dissemination service, etc.

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.603 (2004) | ISO/IEC 16512-1:2005, *Information technology – Relayed multicast protocol: 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 over a single invocation of service.

3.2 IP multicast: A multicast scheme in an IP network supported by multiple multicast-enabled IP routers.

3.3 relayed multicast: A multicast data delivery scheme that can be used in unicast environments; the scheme is based on intermediate multicast agents that relay multicast data from a media server to media players over a tree hierarchy.

3.4 relayed multicast protocol (RMCP): A protocol that supports and manages the relayed multicast data transport.

3.5 RMCP-2 session: An MA set that uses the RMCP to configure the data delivery path.

3.6 multicast agent (MA): An intermediate data transport entity used to relay the multicast application data. Depending on the deployment, an MA may be installed in the same system as a receiving client.

3.7 sender multicast agent (SMA): The MA attached to the sender in the same system or local network.

3.8 receiver multicast agent (RMA): The MA attached to the receiver in the same system or local network.

3.9 head multicast agent (HMA): A representative of the MA inside a local network where the multicast is enabled.

3.10 **session manager (SM)**: An RMCP entity that is responsible for the overall RMCP operations; it may be located in the same system as the media server or located separately from the media server.

3.11 **parent multicast agent (PMA)**: The next upstream MA in the RMCP-2 data delivery path.

3.12 **child multicast agent (CMA)**: The next downstream MA in the RMCP-2 data delivery path.

4 Abbreviations

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

AUTH	Authentication
CMA	Child Multicast Agent
DMA	Dedicated Multicast Agent
HANNOUNCE	HMA announce message
HB	Heartbeat message
HLEAVE	HMA leave message
HMA	Head Multicast Agent
HSOLICIT	HMA solicit message
IP-IP	IP in IP
LEAVANS	Leave answer message
LEAVREQ	Leave request message
MA	Multicast Agent
MAID	Multicast Agent Identification
PMA	Parent Multicast Agent
PPROBANS	Parent probe answer message
PPROBREQ	Parent probe request message
RELANS	Relay answer message
RELREQ	Relay request message
RMA	Receiver Multicast Agent
RMCP	Relayed MultiCast Protocol
SDP	Session Description Protocol
SID	RMCP-2 Session Identification
SMA	Sender Multicast Agent
STANS	Status report answer message
STCOLANS	Status report collect answer message
STCOLREQ	Status report collect request message
STREQ	Status report request message
SUBSANS	Subscription answer message
SUBSREQ	Subscription request message
T/TCP	TCP extensions to Transactions
TCP	Transmission Control Protocol
TERMANS	Termination answer message
TERMREQ	Termination request message
UDP	User Datagram Protocol

5 Overview

The RMCP-2 is an application-level protocol that uses multicast agents (MAs) and a session manager (SM) to support and manage a relayed multicast data transport over a unicast-based Internet. With the help of the SM, the RMCP-2 begins by constructing a relayed multicast control tree that consists of MAs. Consequently with the preconfigured control tree, each MA connects appropriate data channels with each other.

The RMCP-2 entities for a simplex delivery model are described in clause 5.1.

5.1 RMCP-2 entities

The RMCP-2 entities are the same as those described in RMCP Part 1. As shown in Figure 1, each RMCP-2 session constructs a relayed multicast data delivery model with the following entities:

a) one SM;

b) one sender multicast agent (SMA) per sender application;

c) one or more receiver multicast agents (RMAs);

d) one or more sending or receiving group applications.

An SM, which can handle one or multiple sessions simultaneously, can be implemented separately or as a part of other entities in an RMCP-2 session.

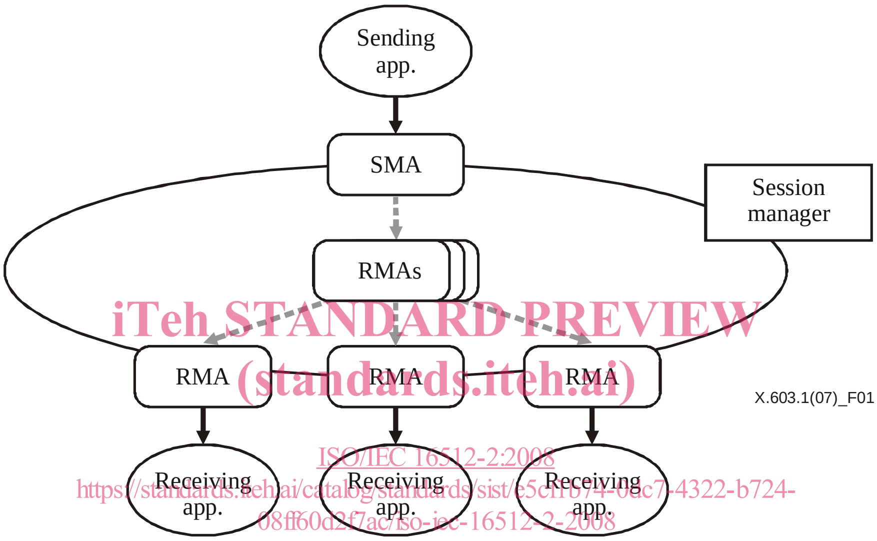

Figure 1 – RMCP-2 service topology

An SM can provide the following functionalities:

a) session initialization;

b) session release;

c) session membership management;

d) session status monitoring.

An MA, which refers to both the SMA and the RMA, constructs a relayed multicast delivery path from one sender to many receivers and then forwards data along the constructed path, can provide the following functionalities:

a) session initialization;

b) session join;

c) session leave;

d) session maintenance;

e) session status reporting;

f) application data relay.

5.2 RMCP-2 protocol block

An SM should exchange control messages with other MAs to control and manage RMCP-2 session. The control messages used by SM should be delivered reliably; otherwise, RMCP-2 session becomes unrecoverable. Figure 2 shows a protocol stack of an SM.

Control module of RMCP-2 SM
TCP
IP (unicast)

Figure 2 – Protocol stack of SM

An MA, which refers to both the SMA and the RMA, constructs a relayed multicast delivery path from one sender to many receivers and then forwards data along the constructed path. An MA consists of an *RMCP-2 control module* and a *data transport module*. The control module establishes the relayed data delivery path. The data transport module sets up a data channel along the path constructed by the control module and then relays data through the channel.

The MA's control module configures the control tree from the SMA to every leaf MAs by exchanging control messages with other MAs. Also the control module is used for session control and management by SM. Figure 3 shows the protocol stack of an MA's control module.

Control module of RMCP-2 MA
TCP
IP (unicast)

Figure 3 – Protocol stack of MA's control module

The MA's data module relays application data along the tree configured by the control module. Figure 4 shows the protocol stack of RMCP-2 data module. Any kind of transport mechanism can be inserted, if needed, because RMCP-2 imposes no restrictions on the type of application data to be delivered.

To ensure that RMCP-2 can adopt any kind of data transport mechanism, two MAs (namely, the parent multicast agent (PMA) and the child multicast agent (CMA)) construct a data delivery path on the control tree by exchanging the data profiles described later.

Data module of RMCP-2 MA
TCP, UDP, IP-IP, SCTP, etc.
IP (unicast or multicast)

Figure 4 – Protocol stack of RMCP-2 data module

The topologies of the two paths for control and data delivery are usually the same, because a data delivery path is constructed along the RMCP-2 control tree. Along the data delivery path, the application data from the SMA can be delivered to each leaf MAs. For more information, Annexes B and C present two feasible real-time and reliable data delivery schemes.

5.3 Simplex delivery model of RMCP-2

The target services of RMCP-2 are *simplex broadcasting services*, such as Internet live TV and software dissemination. In those service models, building an optimal data delivery path from a sender to multiple receivers is important. RMCP-2 can support a simplex data delivery model by using the MA's control and data module.

The data delivery path that RMCP-2 considers is a *per-source relayed multicast tree*. Along the per-source relayed multicast path, a *unidirectional real-time or reliable data channel* can be constructed. Figure 5 shows one of the possible relayed multicast trees configured by RMCP-2 for *simplex real-time or reliable applications*.

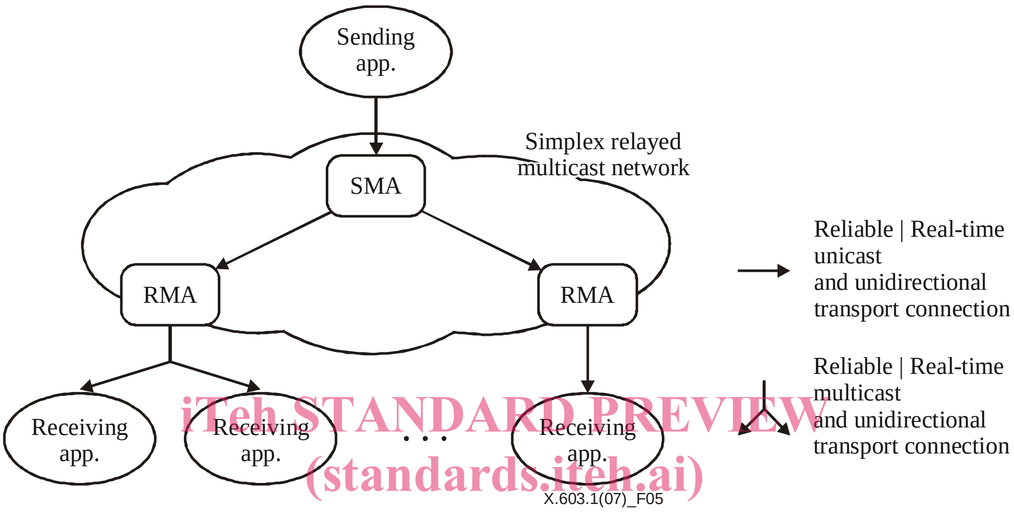

Figure 5 – Relayed multicast tree configured by RMCP-2

5.4 Types of RMCP-2 messages

To construct and maintain a relayed multicast tree, several control messages are exchanged between RMCP-2 peers in a *request-and-answer* manner. Table 1 lists the RMCP-2 control messages according to the appropriate functions.

Table 1 – RMCP-2 messages

Messages	Descriptions	RMCP operations
SUBSREQ	Subscription request	Session initialization
SUBSANS	Subscription answer	
PPROBREQ	Parent probe request	MAP discovery
PPROBANS	Parent probe answer	
HSOLICIT	HMA solicit	HMA election
HANNOUNCE	HMA announce	
HLEAVE	HMA leave	
RELREQ	Relay request	Data delivery
RELANS	Relay answer	
STREQ	Status report request	Session monitoring
STANS	Status report answer	
STCOLREQ	Status collect request	
STCOLANS	Status collect answer	

Table 1 – RMCP-2 messages

Messages	Descriptions	RMCP operations
LEAVREQ	Leave request	Session leave
LEAVANS	Leave answer	
HB	Heartbeat	Session heartbeat
TERMREQ	Termination request	Session termination
TERMANS	Termination answer	

6 Protocol operation

This clause describes the RMCP-2 protocol functions and their operations in details. All the components described in this clause follow the definitions of ITU-T Rec. X.603 | ISO/IEC 16512-1.

6.1 SM's operation

6.1.1 Session initiation

To make the SM create a new session, a content provider (CP) should provide a session profile, which includes details to create a session such as the session name, media characteristics, and the group address. To distinguish the sessions from each other, the SM creates a globally unique session identification (SID). After a successful session creation, the SM returns the SID to the CP. The CPs may announce the session creation by using a web server or email. But the way of session announcement is out of scope this Specification.

After the successful session creation, the SM waits for a subscription request from the MAs. When the SM receives a subscription request from an MA, the SM decides whether to accept the subscription request.

6.1.2 Admission control

On receiving MA's subscription request, firstly the SM checks the SID in the request message, and then determines whether the request is acceptable according to the session policy. RMCP-2 session can be operated privately as well as publicly with some extra information such as system information and authentication information.

When the SID in the MA's SUBSREQ is valid, then the SM checks proposed MAID and proposed data profile. If the MAID proposed by MA has null or duplicated value, then the SM proposes a unique one; otherwise, the proposed MAID will be used during the session. If the proposed data profile cannot be supported, the SM should reject the request with a reason. Otherwise, the SM can negotiate for the most effective data profile and sends back with the negotiated one.

When the MA's SUBSREQ is granted, then the SM responds with a confirmed MAID, NL and session dependent information.

To kick out a specific MA, the SM starts the discard procedure by sending a leave request (LEAVREQ) with a reason code Kicked-Out (KO) and then updates its session member list. Upon receiving SM's LEAVREQ message, MA leaves the session promptly. Figure 6 illustrates the procedure, where the SM sends a LEAVREQ message with the reason code KO and then the MA B leaves the session with notifying its PMA and CMAs of the expulsion.

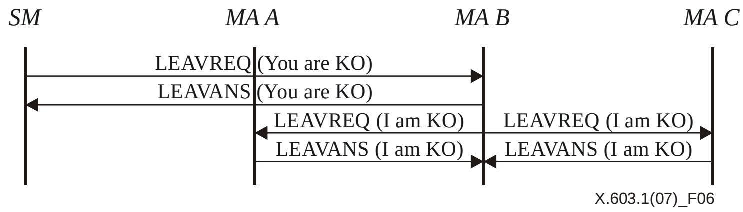

Figure 6 – When MA is kicked out by SM

6.1.3 Session monitoring

The SM can fetch status information of a specific MA by exchanging a status request and answer messages with any specific MA. Upon receiving the status request message, the MA responds with a status answer message that contains the requested information. Figure 7 shows how the SM monitors a specific MA.

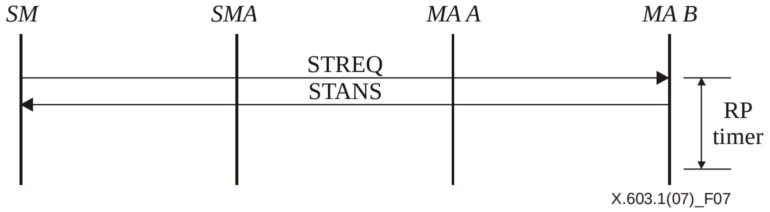

Figure 7 – Tree monitoring – Status report

SM can also collect status information of an entire or a part of a session. In this case, the SM sends a status collect request message to the top MA of the part. Upon receiving the status collect request message, the MA should send a status answer back to the SM with appropriate information on the MA and its children. When the session size is large, the use of this mechanism for the entire session may cause overloading the network and system resources. To limit the scope of the monitoring, the status collect message should contain an option for the depth.

6.1.4 Session termination

The SM's ongoing session may terminate due to one of the following two reasons:

1) administrative request; and

2) SMA's leave.

Figure 8 shows the SM's session termination procedure.

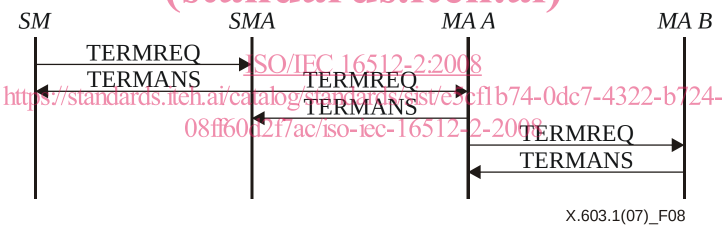

Figure 8 – Session termination issued by SM

Because a RMCP-2 session can continue only when the SMA is alive, the SMA must notify the SM when it leaves. Having been notified SMA's leave, the SM should terminate the session promptly. The session termination caused by SMA's leave is described in 6.2.4.4.

6.2 MA's operation

6.2.1 Session subscription

Subscription is the first stage for an MA to be enrolled in a RMCP-2 session. Each MA must subscribe to the session by sending a subscription request (SUBSREQ) to the SM. Note that the SMA must have finished its subscription before the other MAs and it should act as a root node in the tree hierarchy. At this stage, each MA needs to know details of the session profile, such as the address of the SM and the policy.

Figure 9 shows the procedure of RMCP-2 session subscription procedure. After SMA's successful subscription, RMCP-2 session can be initiated.

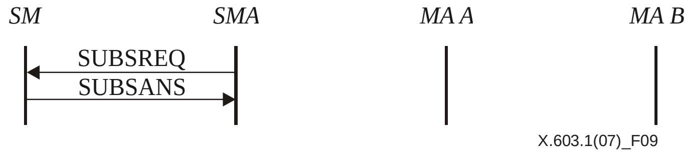

Figure 9 – SMA's subscription

Figure 10 shows the procedure of an MA subscription (for MA A and MA B). To subscribe an RMCP-2 session, each MA sends a SUBSREQ to the SM. Upon receiving SUBSREQ from the MA, the SM decides whether to accept the subscription request. If the request is accepted, the SM responds with a SUBSANS and bootstrapping information such as an NL. Otherwise, it responds with a SUBSANS with appropriate error reason code.

After receiving a successful SUBSANS from SM, the MAs (MA A and MA B) can complete the subscription phase.

Figure 10 – MA's subscription

6.2.2 Map discovery

Since all MAs are logically interconnected, it would be difficult for a MA to know the entire network condition. However, by using map discovery procedures, each MA can explore the other MAs in the RMCP-2 network and measure the distance between itself and the other MAs. The map discovery mechanism consists of two steps. One is used in the multicast-enabled area, such as subnet LAN, and the other is used in the multicast-disabled area such as WAN.

6.2.2.1 Inside multicast-enabled area

It is desirable to assign the nearest node to its PMA. The network distance in RMCP-2 depends on the delay jitter, the hop count and the bandwidth.

Normally, an MA in the same network is closer than other MAs. Each MA looks for a candidate PMA in its local network by multicasting a head multicast agent solicit (HSOLICIT) to a specific pre-assigned address (aka, broadcast) at the beginning. If there is no answer, the MA becomes the HMA, which is a representative of the MA in the multicast-enabled network.

Once an MA becomes a HMA, the HMA announces its existence to the multicast-enabled network by sending periodic HANNOUNCE messages. The HMA sends a HANNOUNCE promptly on receiving HSOLICIT from the multicast-enabled area.

Upon receiving the HANNOUNCE from the HMA, each MA considers that a HMA already exists in the same network and then assumes the HMA as its primary PMA candidate. Figure 11 shows the HMA selection procedure.

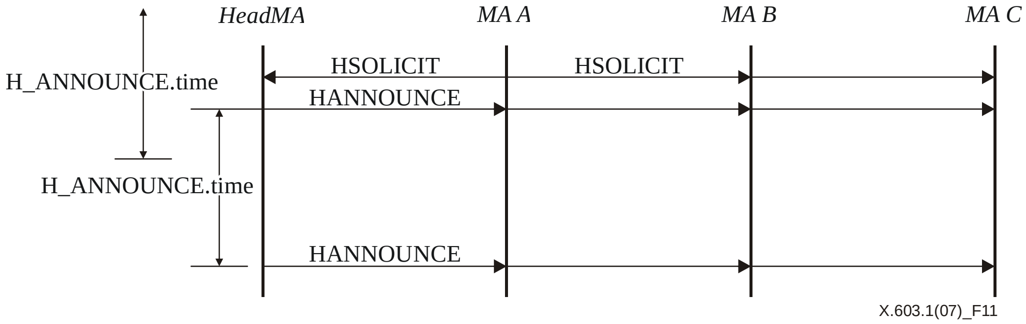

Figure 11 – HMA Solicit and its announcement

Figure 12 shows how an MA becomes a HMA. If there is no HANNOUNCE for a certain time (H_SOLICIT.time × N_SOLICIT), an MA becomes a new HMA and broadcasts a periodic HANNOUNCE every H_ANNOUNCE.time to the multicast-enabled area.

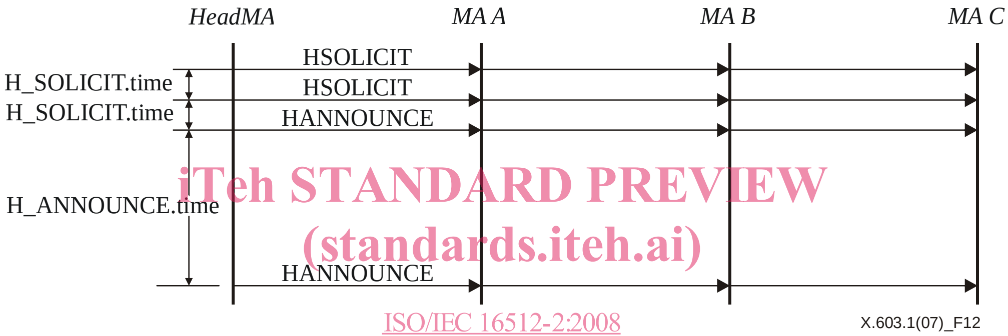

Figure 12 – An MA becomes a new HeadMA

Figure 13 shows how a HMA resumes. Once an MA becomes a HMA, it broadcasts a HANNOUNCE to the multicast-enabled network every H_ANNOUNCE.time.

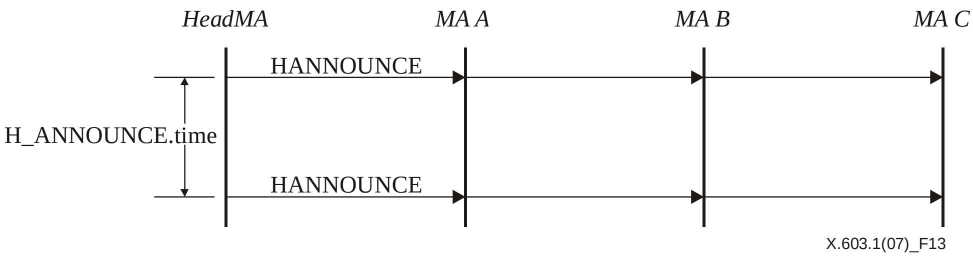

Figure 13 – Periodic head announce

Figure 14 shows how a new HMA is selected. If there is no HANNOUNCE for a certain time (H_ANNOUNCE.time × N_ANNOUNCE), the HMA waits for a HANNOUNCE for a random back-off time. If there is no HANNOUNCE, then the MA becomes the HMA of the multicast-enabled network. However, if there is a HANNOUNCE, then the MA discards the back-off time and selects the HMA as its primary PMA candidate. If there are more than two HANNOUNCE, the earliest HANNOUNCE sender becomes a HMA. If two or more HANNOUNCE have collided, then the HMA should follow the duplication suppression algorithm.