Telecommunications and Information Exchange Between Systems

ISO/IEC JTC 1/SC 6

Document Number:	N13833
Date:	2008-12-23
Replaces:	
Document Type:	Working Draft
Document Title:	Working Draft of ISO/IEC 24793-3 Information Technology – Mobile Multicast Communications: Protocol over Overlay Multicast Networks
Document Source:	Project Editor
Project Number:	
Document Status:	This is the output document of SC 6/WG 7 Montreux meeting.
Action ID:	FYI
Due Date:	
No. of Pages:	35

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Title: Output document of MMC-3 (ISO/IEC 24793-3)

Source: ISO/IEC JTC 1/SC 6/WG 7 Meeting (Montreux, November 2008)

Status: This document is an output document to the MMC-3 (ITU-T X.mmc-3 | ISO/IEC 24793-3) of November 2008 Montreux ISO/IEC JTC 1/SC 6/WG 7 Meeting. This document is based on the output document of Sept. 2008 SC 6/WG 7 and ITU-T Q.1/17 joint meeting which is TD 1484 of ITU-T.

Major modifications are as follows:

- Reconstruct the document to meet the ITU-T | ISO/IEC common text format
- Definition changed by removing unused terminology and adding new terminology
- Insertion of new clause 6.1 MMC-service
- Modification to clause 6.2 MMC entities to concur with the current text
- Insertion of interface types used in MMC-3
- Insertion of new clause 6.5 MMC-3 data delivery model
- Modification to control message table to concur with the current text
- Modification to SM operation in supporting MMA and MN
- Modification to MMA operation to support mobile node management
- Modification to MN operation to support MN management

Summary

This Recommendation describes an application-layer protocol, which constructs multicast tree for data delivery from one sender to multiple receivers over fixed and mobile converged network environment. This specification describes detailed functions and procedures of the protocol. It is expected that MMC-3 can be used as delivery service for applications that require one-to-many data delivery service over fixed and mobile converged network environment; examples of MMC-3 service include mobile IPTV service, mobile NEWS ticker service.

Contents

Introduction

<Optional – This clause should appear only if it contains information different from Scope and Summary>

The demands of multimedia services in the mobile environment seem to be grown enormously in the next generation network. Among the multimedia services can be considered, multimedia streaming services are expected the most influence services.

INTERNATIONAL STANDARD <Nbr>
ITU-T RECOMMENDATION <Nbr>

Information Technology –
Mobile Multicast Communications:
Protocol over Overlay Multicast Networks

1 Scope

This Recommendation | International Standard describes protocol over overlay multicast networks, which can be used to support a variety of multimedia multicasting services by constructing overlay multicast path over the IP-based wireless mobile networks as well as the wired fixed networks; this protocol focuses on one-to-many data delivery service types.

This Recommendation | International Standard specifies the protocol over overlay multicast, which describes the protocol operation and message types.

This Recommendation | International Standard specifies the followings:

a) Overview of protocol; which introduces protocol entities, protocol blocks and message types

b) Protocol operation for one-to-many data delivery

c) Detailed messages and parameters

Editor's Note: Contributions are requested to progress this text.

2 Normative references

The following ITU-T Recommendations and International Standards contain provisions that, through references in the text, constitute provisions of this Recommendation | International Standard. At the time of publication, the editions indicated were valid. All Recommendations and Standards are subject to revision, and parties to agreements based on this Recommendation | International Standard are encouraged to investigate the possibility of applying the most recent edition of the Recommendations | International Standards listed below. IEC and ISO members maintain registers of currently valid International Standards. The Telecommunication Standardization Bureau of the ITU-T maintains a list of currently valid ITU-T documents.

– ITU-T Recommendation X.603 (2004) | ISO/IEC 16512-1 : 2004, Information technology – Relayed multicast protocol: Framework

– ITU-T draft Recommendation X.603.1 | ISO/IEC 16512-2, Information technology – Relayed multicast protocol: Specification for for simplex group applications

3 Definitions

3.1 Terms defined elsewhere

This Recommendation|International Standard uses the following terms defined elsewhere:

3.1.1 RMCP session [ITU-T X.603]: A set of MAs that use the RMCP to configure the data delivery path.

3.1.2 Sender multicast agent (SMA) [ITU-T X.603]: The MA attached to the sending application in the same system or local network.

3.1.3 Session identification (SID) [ITU-T X.603]: Corresponds to group name and identifies RMCP session uniquely.

3.1.4 Session manager (SM) [ITU-T X.603]: An RMCP entity that is responsible for the overall RMCP operation; it may be located in the same system as the sending application or located separately from the sending application.

3.1.5 Simplex [ITU-T X.603]: Wherein only one sender is send only and all others are receive only.

3.1.6 Multicast agent (MA) [ITU-T X.603]: An intermediate RMCP entity used to support and manage a relayed multicast data transport over a unicast based Internet; an MA may be installed in the same system as a receiving application.

3.1.7 MobileIP [IETF RFC 3344]: An Internet Engineering Task Force (IETF) standard communications protocol that is designed to allow mobile device users to move from one network to another while maintaining a permanent IP address.

3.2 Terms defined in this Recommendation

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

3.2.1 Mobile multicast agent (MMA): A special MA used to support mobile nodes.

3.2.2 Mobile node (MN): A leaf node of overlay multicast tree; whose location and point of attachment to the Internet may frequently be changed.

3.3.3 Mobile node identification (MNID): Unique value used to identify MN for a certain session.

4 Abbreviations

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

CMA	Child Multicast Agent
HMA	Head Multicast Agent
IP-IP	IP in IP
KO	Kick-Out
MA	Multicast Agent
MAID	Multicast Agent Identification
MCS	Multicast Communication Server
MMA	Mobile Multicast Agent
MMC	Mobile Multicast Communications
MN	Mobile Node
MNID	Mobile Node Identification
PMA	Parent Multicast Agent
PoA	Point of Access
RMCP	Relayed Multicast Protocol
SDP	Session Description Protocol
SID	Session Identification
SM	Session Manager
SMA	Sender Multicast Agent
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
MN	Mobile Node
MMA	Mobile Multicast Agent
MMC	Mobile Multicast Communications

5 Conventions

<None>

6 Overview

6.1 MMC-3 services

MMC-3 is an application-level protocol that is expanded from X.603.1 to support simplex group communication services over fixed and mobile converged network environment. To support both fixed and mobile converged network enviuronment, MMC-3 uses the MMA, Mobile multicast agent, to support mobile node. The entities of MMC-3 protocol configure an efficient data delivery path for one-to-many group communications. MMC-3 entities forward group data to each participant along the constructed delivery path.

MMC-3 can support various application services that require one-to-many group communications over fixed and mobile converged network environment such as mobile IPTV or mobile NEWS ticker service.

오류! 참조 원본을 찾을 수 없습니다. shows a typical service model of MMC-3 for supporting one-to-many group communications service over fixed and mobile converged network. The MMC-3 protocol can also be used in a wireless environment where MMA does not exist. In MMC-3, the wireless environment where MMA does not exist is called non-MMA region.

As shown in **오류! 참조 원본을 찾을 수 없습니다.**, the MMC-3 protocol can provide one-to-many group communications service in both MMA region and non-MMA region. The MMC-3 protocol utilizes the multicast capability inside the MMA region and, also, provides multicast capabilities to entities in the non-MMA region.

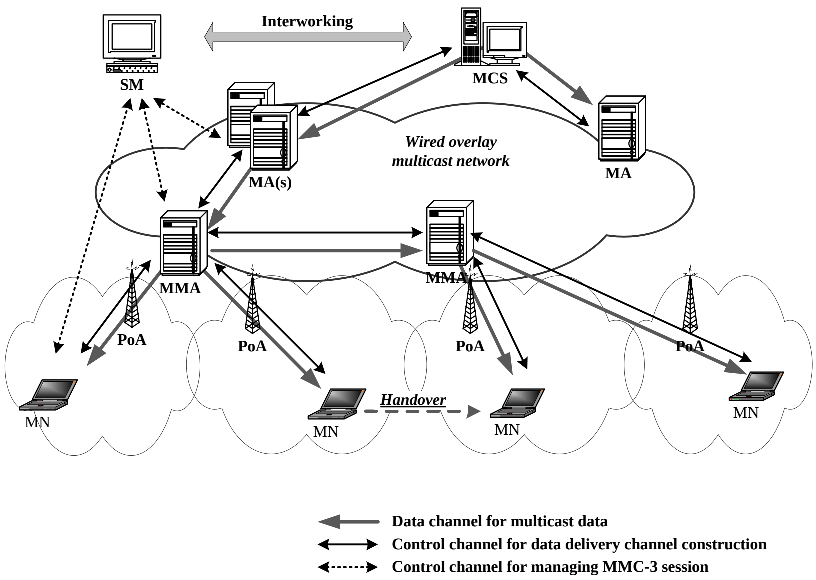

Figure 1 – MMC-3 service model

The main entities of the MMC-3 protocol are session manager(SM) and multicast agent (MA) and mobile multicast agent (MMA) and mobile node (MN). The SM manages the multicast tree and multicast session. The MA is an intermediate node that provides data delivery capability. The MMA provides multicast service to MNs and MN is a user device.

The following features support the one-to-many group communications over fix and mobile converged network.

a) MMC-3 constructs a logical control tree by using one or more MAs; the control tree supports the transmission of data in a reliable or real-time manner.

b) MMC-3 has the capability of selecting optimal peers; because the MMC-3 control tree consists of logical links between MAs, and each MA configures a logical links based on the selected peers. The selection of optimal peers can be based on various metrics; example of such metrics includes hop count, delay, and/or bandwidth.

c) MMC-3 supports pure IP multicast, NAT/Firewall, and different versions of IP.

d) MMC-3 allows participants to join or leave at any time during a session.

e) MMC-3 manages the participants of a session; the capability of managing the session includes membership monitoring and expulsion of members.

f) MMC-3 provides an auto-configuration mechanism for the group communications path.

g) MMC-3 provides network fault detection and service recovery.

h) MMC-3 provides multicast service to MN through MMA.

i) MMC-3 supports seamless handover of MN.

j) MMC-3 has various ways of managing the session; e.g., tightly or loosely.

6.2 MMC-3 entities

The following figure shows an example network configuration of the MMC functional entities over relayed multicast; MCS, MA, MN, and SM. MA can be categorized by MA in wireless access network which is called MMA and MA in relayed multicast backbone network. As shown in Figure 1, one MMA can handle one or more wireless access network. It is noted in the figure that the network entities are hidden such as multicast routers and MA can be implemented as an end-system, server, or hardware set-top box; the ways of implementing MA are out of this document's scope.

A SM can provide the following functionality:

a) Session initialization;

b) Session termination;

c) Membership management;

d) Monitoring session status.

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

a) Session initialization;

b) Session subscription;

c) Session join;

d) Session leave;

e) Session management;

f) Reporting session status;

g) Data delivery.

To support MN, MMA should provide the following additional functionalities:

a) MMA announcement;

b) Support session join of MN;

c) Support MN handover;

d) Data channel differentiation;

e) MN management

A MN attaches to a relayed multicast delivery path and provides the following functionality:

a) Session subscription;

b) Session join;

c) Session leave;

d) Session maintenance;

e) Wireless access network movement and fast handover.

6.3 Protocol blocks

MMC-3 uses two different types of protocol blocks. The first block is used for controlling MMC-3 session, and the second block is used for delivering group data. Since SM is used to control the MMC-3 session, SM only has a control module. On the other hand, since MA/MMA is used for control and data delivery, MA/MMA consists of two modules, which are control module and data module. MN is used to receive group data. To receive group data, MN consists of both control module and data module.

Figure 2 shows the three types of path and interfaces that are used in MMC-3.

– MMC-3 control path between SM and MA/MMA/MN and between MAs/MMAs or MN and MMA;

– Data path between MA/MMA data modules or MN data module and MMA data module;
– Local interfaces inside the MA/MMA/MN; that is, between the control module and the data module.

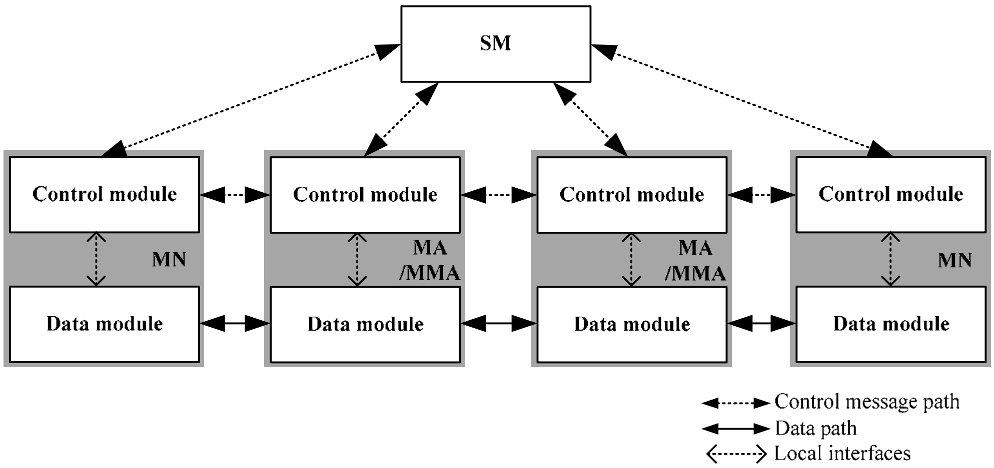

Figure 2 – Three types of interfaces in MMC-3

MMC-3 needs to use reliable protocol transport in exchanging messages to construct a robust and reliable multicast session. Thus, MMC-3 uses TCP in transmitting control messages.

SM should exchange control messages with other MAs/MMAs/MNs to control and manage a group communication session. The control messages used by SM should be delivered reliably otherwise the session becomes unrecoverable. For reliable delivery of control messages, SM uses TCP. The following Figure 3 shows a protocol stack of SM.

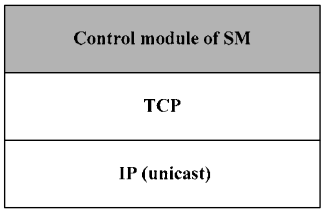

Figure 3 – Protocol stack of SM

MA, which refers to both the MA and the MMA, constructs a relayed multicast delivery path from one sender to many receivers and then forwards data along the constructed path. MA consists of a control module and a data module. The control module establishes the relayed data delivery path. The data 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 MCS to every leaf MMAs by exchanging control messages with other MAs; also the control module is used for session control and management by SM.

The MA’s data module relays application data along the tree configured by the control module. Data module of MMA is used to provide multicast service to MN. Figure 4 shows the protocol stack of MA’s data module; any kind of transport protocol can be used if needed.

To ensure that any kind of data transport mechanism can be adopted, two MAs (namely, the upstream MA and downstream MA) construct a data delivery path on the control tree by exchanging the data profiles described later.

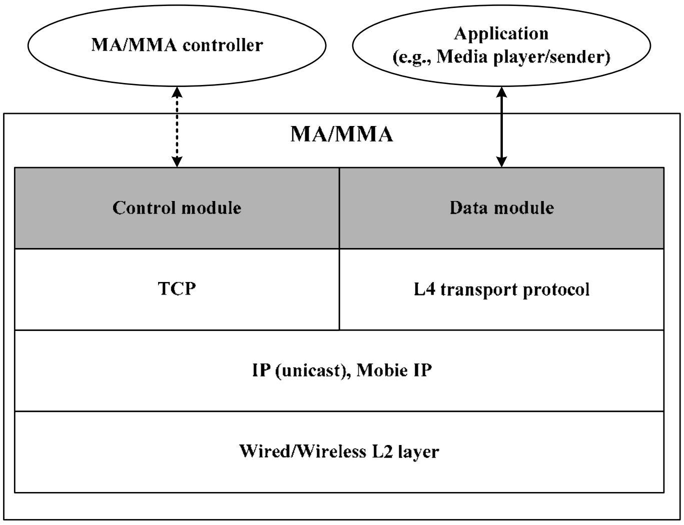

Figure 4 – Protocol stack of MA/MMA

The topologies of the two paths for control and data delivery are usually the same, because a data delivery path is constructed along the control tree. And then the application data from the MCS can be delivered to each leaf MMA. At last, each MMA which receives application data from MCS can provide the received application data to MN.

MN regists to a MMA and then receives multicast data. An MN consists of a control module and a data module. The control module enables registration to MMA and movement. And the data module enables data receiving from MMA.

Figure 5 shows the protocol stack of an MN.

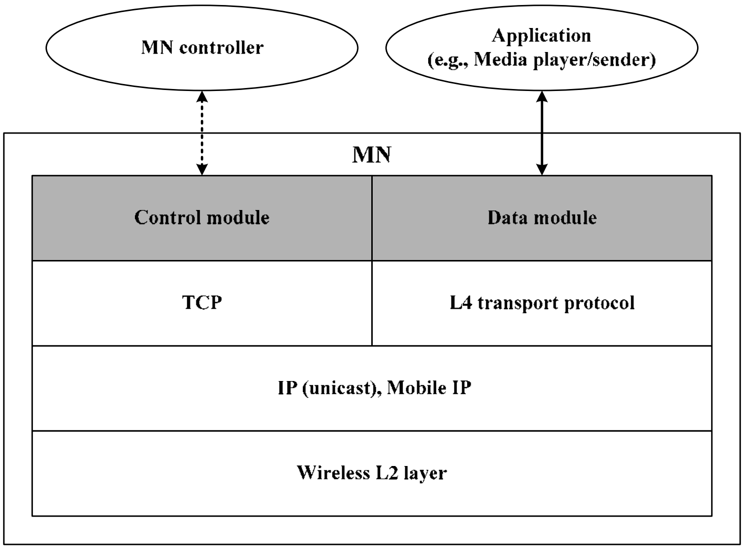

Figure 5 – Protocol stack of MN

The MN’s data module receives application data from the MMA. Any kind of transport mechanism can be inserted if needed.

It is important that MN does not join the control tree. Registration to MMA does not mean joinning the control tree. Since MN can move frequently, MN must not join the control tree for preventing control overhead.

6.4 MMC-3 control model

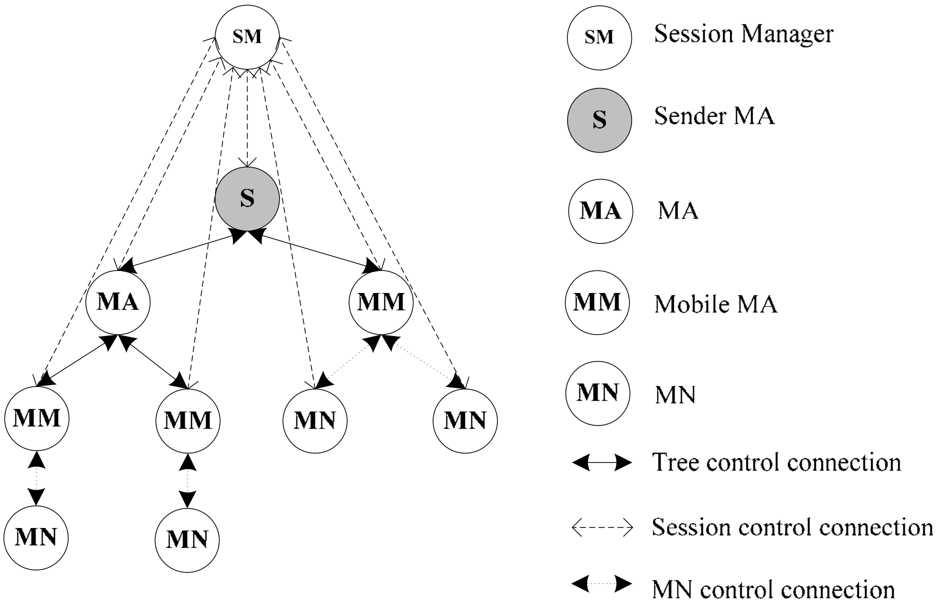

Figure 6 – Control connection between MMC-3 entities

MMC-3 control tree consists of Sender MA and zero or more MAs and MMAs. The following are the control connections that exist in the control tree:

- Connections in MA/MMA forming tree;
- Direct connection between SM and MAs/MMAs.

As mentioned above, The MN does not join the control tree. However there exists direct connection beteween SM and MNs for session subscription.

6.5 MMC-3 data delivery model

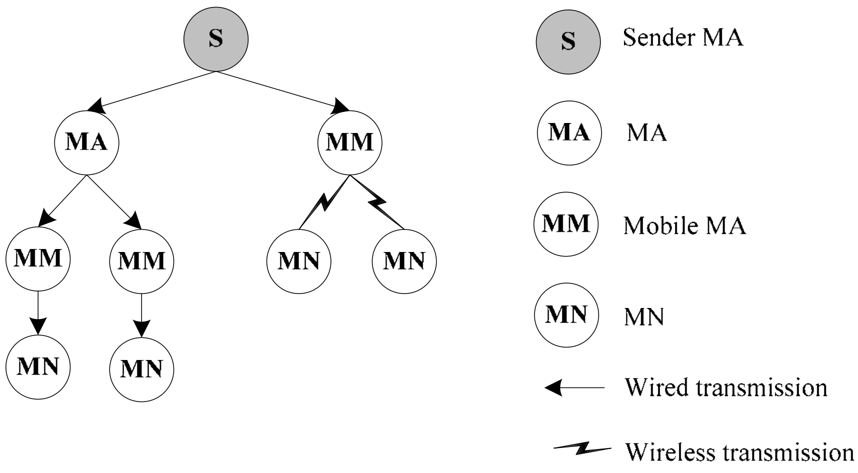

Figure 7 – MMC-3 data delivery model

Figure 7 shows the data delivering model. The MMA transmits the data to MNs through wireless transmission. It is possible that the MMA transmits the data to MNs through wired transmission if MN is in the non-MMA region.

6.6 Types of control messages

Table 1 lists the MMC-3 messages with its meaning and the operation that is used.

Table 1– MMC-3 messages

Messages	Meaning	Operation
SUBSREQ	Subscribe request	Session initiation
SUBSANS	Subscribe answer	
PPROBREQ	Parent probe request	Neighbor discovery
PPROBANS	Parent probe answer	
RELREQ	Relay request	Data channel control
RELANS	Relay answer	
LEAVREQ	Leave request	Session leave
LEAVANS	Leave answer	
TERMREQ	Termination request	Session termination
TERMANS	Termination answer	
HSOLICIT	Head MA solicit	Management for multicast enabled network
HANNOUNCE	Head MA announce	
HLEAVE	Head MA leave	
HB	Heartbeat	Session tree maintenance
STREQ	Status report request	Session monitoring
STANS	Status report answer	
STCOLREQ	Status collect request	
STCOLANS	Status collect answer	
mADVERTISE	MMA advertisement	MMA announcement
mSOLICIT	MMA solicitation	MMA solicitation
mREGISTREQ	MN registration request	MN registration
mREGISTANS	MN registration answer	

7 Protocol operation

7.1 Session manager’s operation

7.1.1 Session initiation

To make the SM create a new session, a multicast communication server (MCS) 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 globally unique session identification (SID). After a successful session creation, the SM returns the SID to the MCS. The MCSs 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/MNs. When the SM receives a subscription request from an MA/ MN, the SM decides whether to accept the subscription request.

7.1.2 Admission control

On receiving subscription request from MA/MN, firstly the SM checks the SID in the request message, and then determines whether the request is acceptable according to the policy defined by the MMC-3 service administrator. A policy can be any criteria that can determine if the requesting MA/MN is a legitimate MMC-3 participant. MMC-3 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 subscription request is valid, then the SM checks proposed MAID (MNID, in cases of MN) and proposed data profile. If the MAID/MNID proposed by MA/MN has null or duplicated value, then the SM proposes a unique one; otherwise, the proposed MAID/MNID 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 subscription request from MA/MN is granted, then the SM responds with a confirmed MAID/MNID, neighbor list and session dependent information.

It is important that neighbor list may vary according to subscription requestor. If the MA, including MMA, requests session subscription, the SM gives the list of MAs that serves requesting session. If the MN requests session subscription, the SM gives the list of MMAs that serves requesting session.

To kick out a specific MA/MN, 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/MN leaves the session promptly. Figure 8 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. If the MN which is in MMA region receives a leave request from the SM, it leaves the session promptly without any notification. If the MN which is in non-MMA region receives a leave request, it leaves the session with notifying its serving MMA of the expulsion.

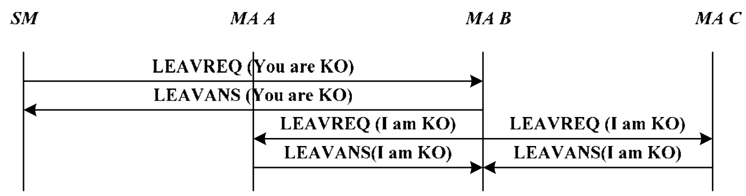

Figure 8 – When MA is kicked out by SM

7.1.3 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 9 shows how the SM monitors a specific MA.

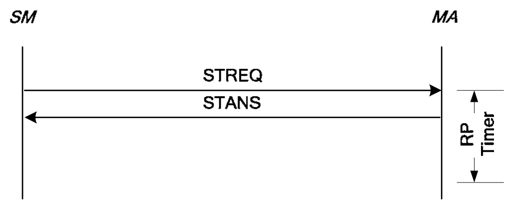

Figure 9 – Tree monitoring – Status report

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.

7.1.4 Session termination

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

a) Administrative request;

b) SMA's leave.

Figure 10 shows the SM's session termination procedure.

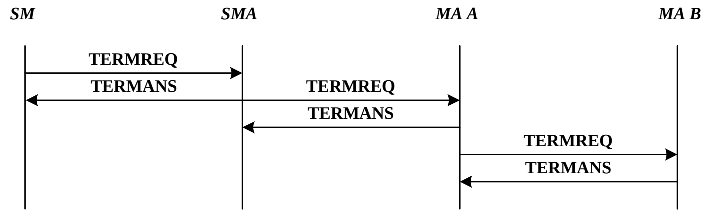

Figure 10 – Session termination issued by SM

Because a MMC-3 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.

7.2 Multicast agent’s operation

7.2.1 Session subscription

Subscription is the first stage for an MA to be enrolled in a MMC-3 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 11 shows the procedure of MMC-3 session subscription procedure. After SMA's successful subscription, MMC-3 session can be initiated.

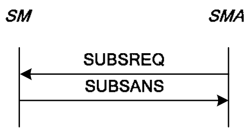

Figure 11 – SMA's subscription

Figure 12 shows the procedure of an MA subscription (for MA A and MA B). To subscribe an MMC-3 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.

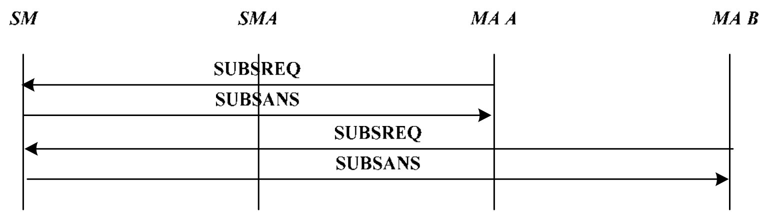

Figure 12 – MA's subscription

7.2.2 Neighbor discovery

Since all MAs are logically interconnected, it would be difficult for a MA to know the entire network condition. However, by using neighbor discovery procedures, each MA can explore the other MAs in the MMC-3 network and measure the distance between itself and the other MAs. The neighbor discovery mechanism consists of two steps. One is used in the multicast area, such as subnet LAN, and the other is used in the unicast area such as WAN.

7.2.2.1 Multicast area

It is desirable to assign the nearest node to its PMA. The network distance in MMC-3 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 network.

Once an MA becomes a HMA, the HMA announces its existence to the multicast network by sending periodic HANNOUNCE messages. The HMA sends a HANNOUNCE promptly on receiving HSOLICIT from the multicast 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 13 shows the HMA selection procedure.

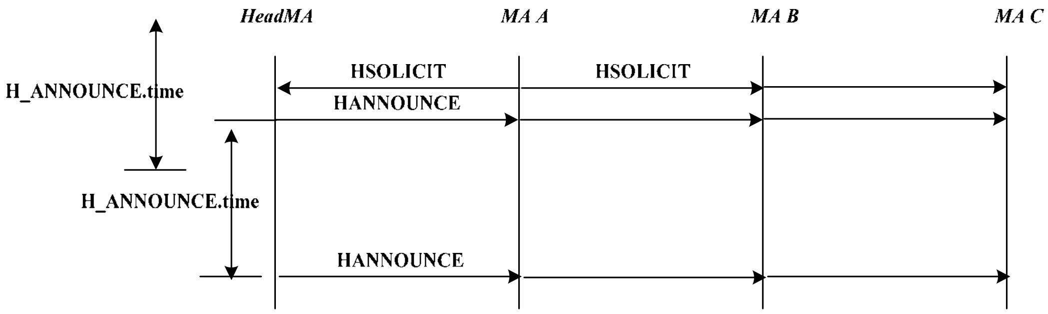

Figure 13 – HMA Solicit and its announcement

Figure 14 shows how an MA becomes a HMA. If there is no HANNOUNCE for a certain time (H_SOLICIT.time x N_SOLICIT), an MA becomes a new HMA and broadcasts a periodic HANNOUNCE every H_ANNOUNCE.time to the multicast area.

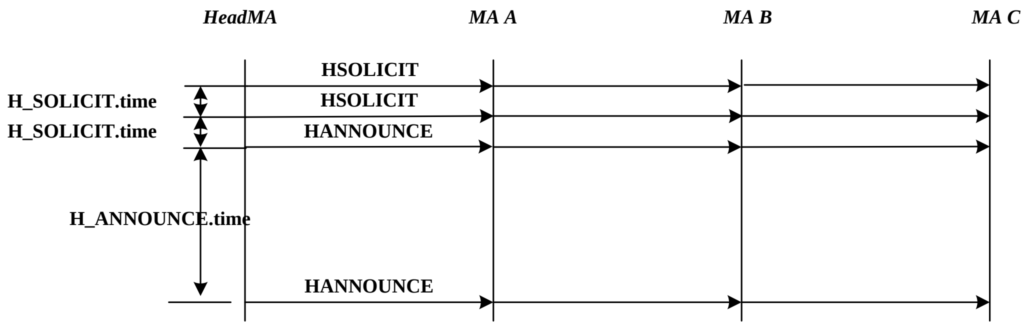

Figure 14 – MA becomes a new HeadMA

Figure 15 shows how a HMA resumes. Once an MA becomes a HMA, it broadcasts a HANNOUNCE to the multicast network every H_ANNOUNCE.time.

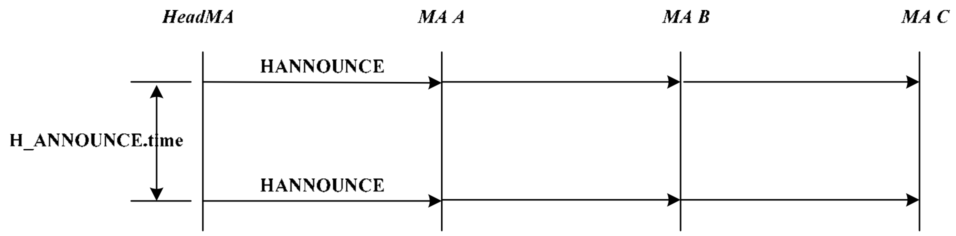

Figure 15 – Periodic head announce

Figure 16 shows how a new HMA is selected. If there is no HANNOUNCE for a certain time (H_ANNOUNCE.time x 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 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 HMA selection rule. The HMA selection rule is implementation dependent, since the HMA selection criteria can be application or service dependent.

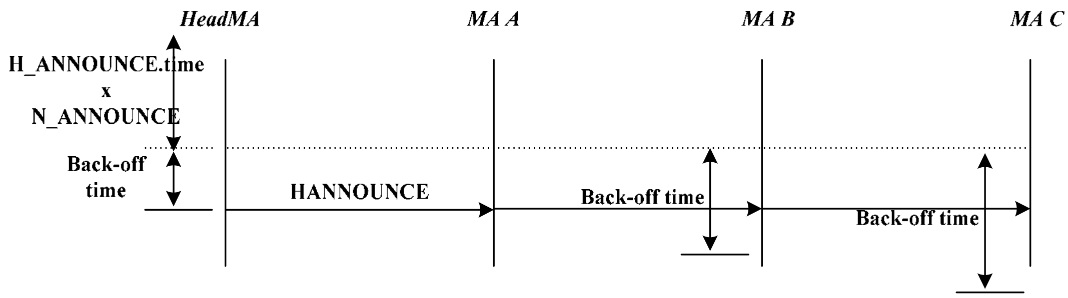

Figure 16 – New HMA selection

7.2.2.2 Unicast area

Each MA should start neighbour discovery procedure based on the initial bootstrapping information given by the SM. As shown in Figure 17, each MA can gradually learn the MMC-3 tree topology by exchanging the tree information of each MA.

The basic neighbor discovery mechanism is as follows: first, by using the PPROBREQ and PPROBANS, each MA can exchange a certain number of NLs at every interval (PPROBE.time). Because of the finite system resource of each MA, the maximum number of NLs to be exchanged should be bounded.

To prevent each MA suffered from PPROBREQ implosion, the maximum number of PPROBREQ messages for a certain period should be limited as N_MAX_PROBE.

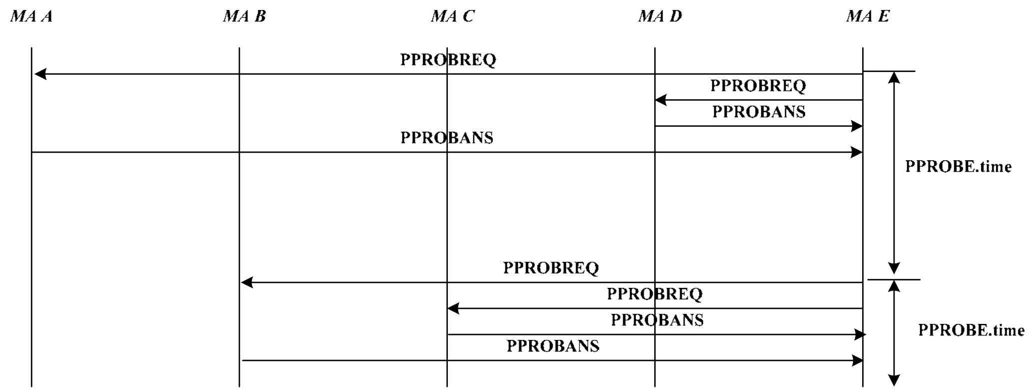

Figure 17 – Protocol sequence of neighbor discovery

7.2.3 Tree join

Tree join procedure enables each MA (both MA and MMA) to choose PMA inside a subscribed MMC-3 session. Figure 39 shows how an MA selects its PMA based on the NL given by the SM. The joining MA (MA E) sends a PPROBREQ to one or more nodes listed in the NL (MA A, C, and D) and awaits a successful PPROBANS. Upon receiving a PPROBANS, the MA E can select the nearest MA. In Figure 39, the joining MA (node E) considers that the MA D is the best and then chooses the MA D as its PMA. After a PMA is selected, the joining MA (node E) will send to the MA D a RELREQ, which contains a proposed data profile.

If the RELREQ is acceptable, the MA D responds with a successful RELANS, which includes the negotiated data profile to be used. Otherwise, the MA D returns a reason code of the rejection.

Upon receiving a successful RELANS, data channel between the MA D and MA E is established according to the negotiated data profile. Otherwise, the MA E should try the second optimal PMA candidate.

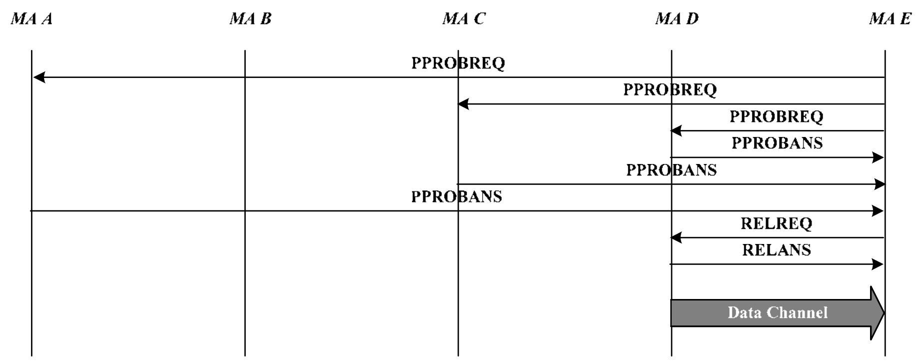

Figure 18 – Protocol sequence of successful tree join

If no MA wants to relay data to the joining MA, the joining MA can retry tree join procedure after a certain period. The retrial time can be set by the user, though this issue is beyond the scope of this Specification. Figure 19 shows when all the MAs listed in the NL given by the SM rejected node E's relay request. However MA E already learned about the existence of MA B during previous exchanges of PPROBREQ and PPROBANS, it can restart the joining procedure from MA B.

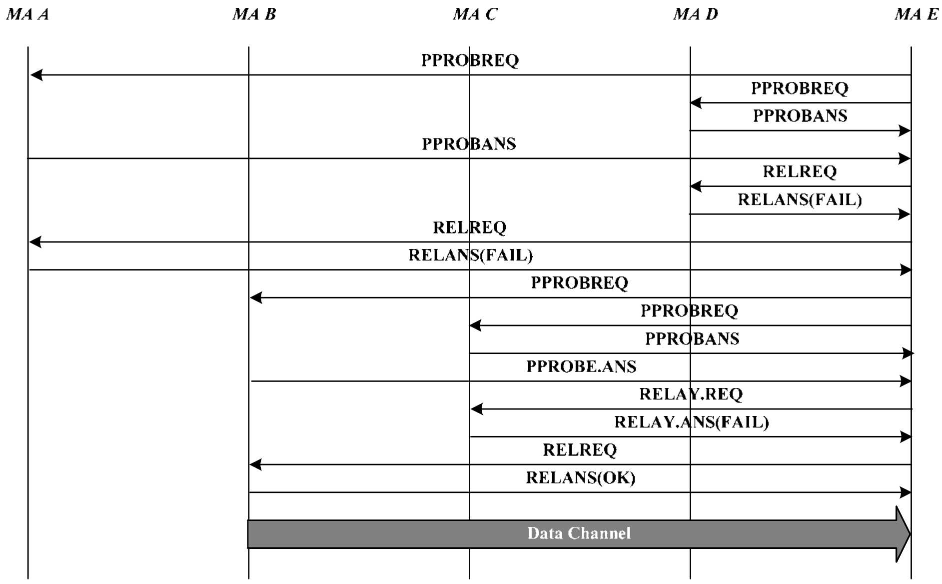

Figure 19– Sequence of unsuccessful tree join and retrial

7.2.4 Leave

A MA may leave a session during the session lifetime. To make a MMC-3 tree robust, each MA should notify its departure to the PMA and CMAs. Upon receiving this notification, the PMA and each CMA should follow the appropriate procedure.

The MMC-3 considers four types of departure. The first one refers to an MA that leaves the session at the request of a service user. The second one refers to an MA that leaves its PMA to switch parents. The third one refers to the expulsion of an MA from its PMA or SM. The final one refers to the departure of an SMA from a session. The detailed operations for the cases are described in the following subclauses.

7.2.4.1 When MA leaves a session

MAs may leave a session at any time during the session's lifetime. Before leaving, an MA must notify the PMA and CMAs of its departure. The PMA deletes the node from its CMA list and reserves a space for a new CMA.

a) MA leave in the unicast area

To leave a session, an MA sends a LEAVREQ to its CMAs. Each CMA who receives the LEAVREQ should promptly start to connect to an alternative PMA by sending a RELREQ to the PMA candidate. If successful, each CMA sends its old PMA a LEAVANS.

Figure 20 shows how a MA leaves a session in unicast area. In this scenario, the procedures of leaving for a non-HMA and the HMA are the same, except the HMA follows the HLEAVE exchanging sequence.

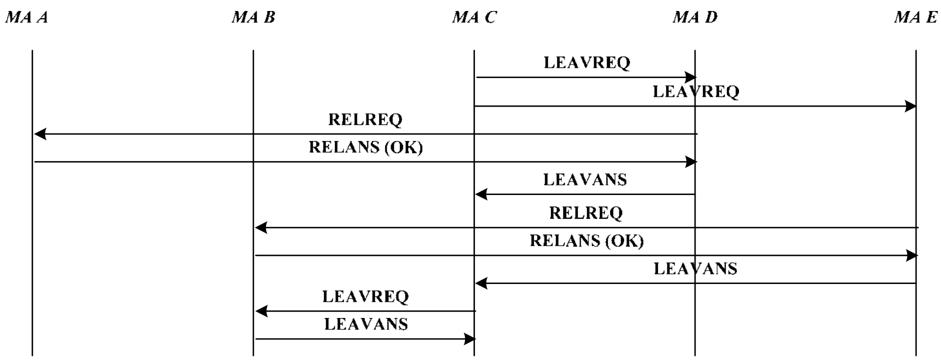

Figure 20 – MA leave in the unicast area

b) MA leave in the multicast area

There are two cases of MA's leaving within a multicast area. The first case is of HMA's leaving and the other is of MA's leaving. Whenever the HMA of a multicast area wants to leave a session, it should notify its departure to the CMAs inside the local network as well as to the CMAs and the PMA in the unicast network.

Figure 21 shows how the MA C, which acts as HMA, leaves a session where the multicast data delivery scheme is used. The HMA (MA C) sends a LEAVREQ to its direct CMA (MA F) in the unicast network. Upon receiving the LEAVREQ, MA F starts to switch parents and responds to MA C with a LEAVANS as well as multicasts a HLEAVE with an empty HMA candidate list to the local network. The HLEAVE message is used to announce the departure of the HMA.

Upon receiving the HLEAVE from HMA, both MA D and MA E from Figure 21 wait for a certain back-off time before multicasting the HANNOUNCE. The MA D sends the HANNOUNCE for the first time and becomes a new HMA. This step occurs because the MA D has a shorter back-off time than any other MA. Because the leaving MA C is a point which is connected to unicast network, the MA D should undertake the role of the MA C by connecting to the PMA in the unicast network. Figure 21 shows how the MA D selects for its parent the MA B, which is the PMA of the MA C.

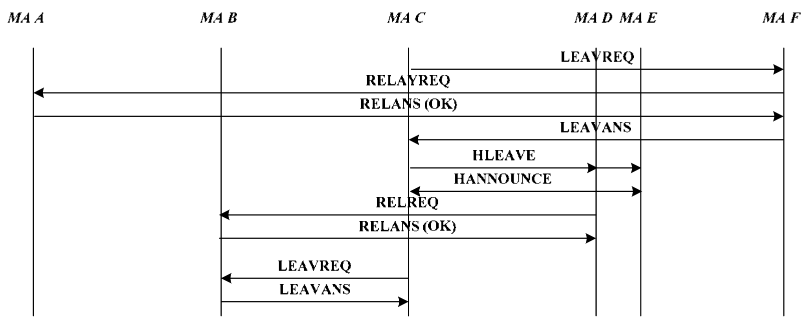

Figure 21 – MA leave in the multicast area

Whenever any non-HMA of a multicast area wants to leave a session, it silently leaves the session. The MA D or MA E from Figure 21 does not need to notify other MAs of its departure.

7.2.4.2 When MA leaves from its PMA – for parent switching

An MA that wants to switch its PMA may leave its current PMA. In this case, the MA does not need to send a LEAVREQ to its CMAs. The CMAs do not need to know about the departure as long as they successfully receive data. To switch PMA, the MA sends a RELREQ to the other PMA candidate. An old PMA that receives a LEAVREQ with the reason code set to PS (parent switching) deletes the leaving MA from its CMA list but keeps the information of the departing MA in its NL because the leaving MA is still alive in the session.

Figure 22 shows how an MA switches its parents. Note that an MA can switch parents only when it receives a HB to keep tree unchanged. The HB mechanism is described in 7.2.5.1.

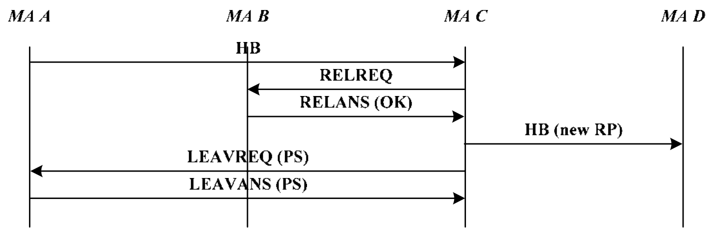

Figure 22 – MA's leaving for parent switching

7.2.4.3 When MA is kicked out

MMC-3 has a mechanism for discarding certain MAs. For example, when a network manager wants the SM to discard a specific MA; and when an MA expels a CMA after it was aware that it cannot support more CMAs.

a) Expulsion of an MA by its PMA

A PMA can expel one of its CMAs when the PMA suffers from depleted system resources and can no longer feed its CMA, or when the PMA finds that one of its CMAs has depleted the system resources. An MA should find another PMA candidate, which would allow for a new CMA.

Figure 23 shows an example of a message flow. First, a PMA, namely the MA C, sends a LEAVREQ with a reason KO to expel MA D. The MA D searches other PMAs and sends a relay request. After switching parents, MA D transmits a LEAVANS to its old PMA.

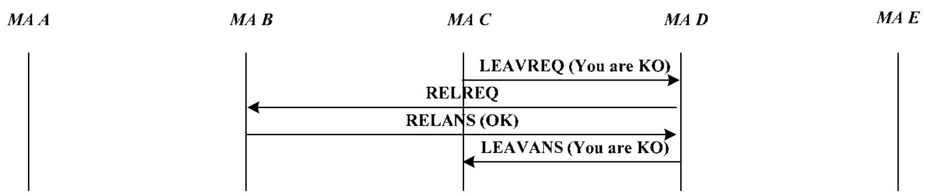

Figure 23 – When MA is kicked out by its PMA

b) Expulsion of an MA by the SM

The SM can discard any MA by sending a LEAVREQ with a reason kicked-out (KO). Upon receiving LEAVREQ from SM, an MA must leave the session promptly. After the expulsion, the SM should update its session member list.

In the message flow shown in Figure 24, the SM tells MA B to leave by sending a LEAVREQ with a reason KO. MA B must leave the session but, before leaving, MA B must notify its PMA and CMAs of its expulsion.

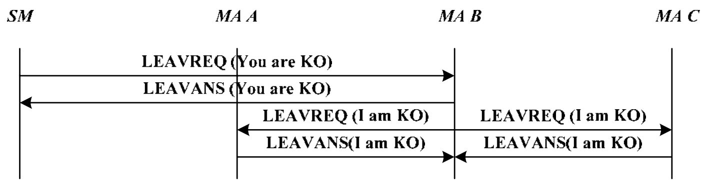

Figure 24 – When MA is kicked out by SM

7.2.4.4 When SMA leaves the session

Because an MMC-3 session cannot exist without an SMA, an SMA never leaves a session before the session is terminated. In this case, when the SMA leaves the session, the session should be terminated.

Figure 25 shows the departure procedure of an SMA from a session. The SMA sends a LEAVREQ to the SM. Upon receiving the LEAVREQ from the SMA, the SM removes the session information and then replies with LEAVANS. Upon receiving the LEAVANS from the SM, the SMA sends a LEAVREQ with reason SMA leave to its direct CMAs. The LEAVREQ with reason SMA leave should be relayed downward promptly to make MMC-3 session terminated.

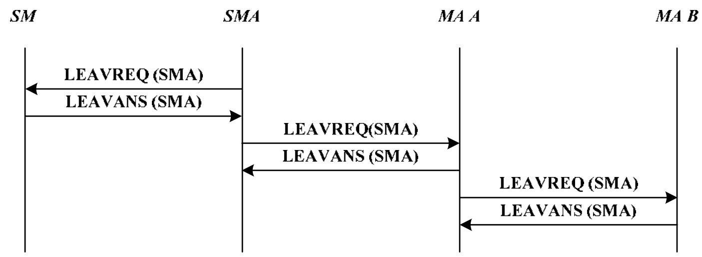

Figure 25 – SMA's leaving

7.2.5 Maintenance

7.2.5.1 Heartbeat

The purpose of the heartbeat is to keep the constructed MMC-3 tree robust. The heartbeat, which gives unified synchronizing information to the session, helps each MA detect whether the session is currently alive. It also contains useful information on the data delivery path, named ROOTPATH. The ROOTPATH includes a relayed data path which follows the tree hierarchy.

Figure 26 shows the MMC-3 heartbeat procedure. In this procedure, the SMA sends the HB, along the tree, to its descendants; each descendant then appends the hop information, which may include MAID, per-hop network distance and system information such as in-and-out bandwidth, affordable number of CMA etc., to the HB and forwards the modified HB to its descendants. Finally the ROOTPATH contains all the MAs visited along the tree.

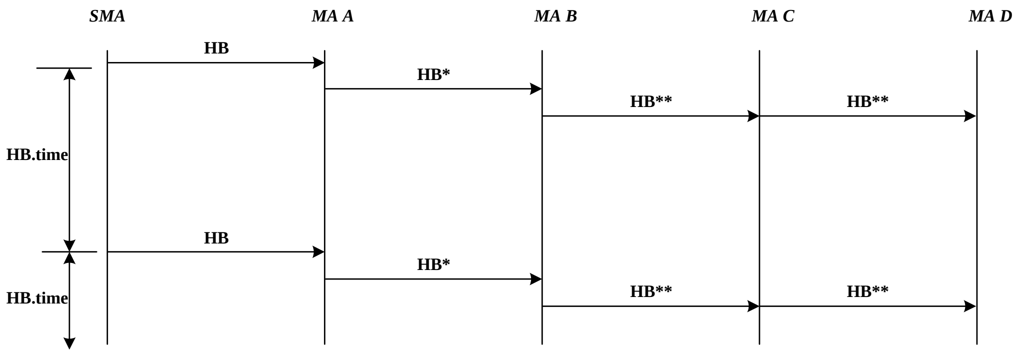

Figure 26 – Heartbeat

7.2.5.2 Monitoring

MMC-3 has two types of monitoring mechanisms. The first one, which is shown in Figure 27, monitors a specific MA. The other one, which is shown in Figure 28, monitors a part of the tree through a specific MA.

Figure 27 shows how an SM monitors a specific MA. In this procedure, the SM sends an STREQ to MA B and requests one or more specific types of status information from MA B. In response, MA B sends the SM a STANS with the requested information.

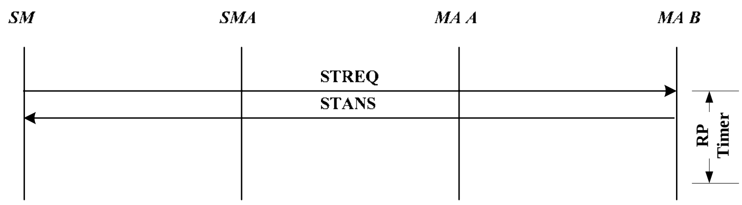

Figure 27 – Tree monitoring by status report

Figure 28 shows how the SM queries the scoped area of a tree. That is, the SM asks for merged information on the scoped area of a tree by sending an STREQ to a specific MA (SMA and MA A each) to collect status information for the scoped area.

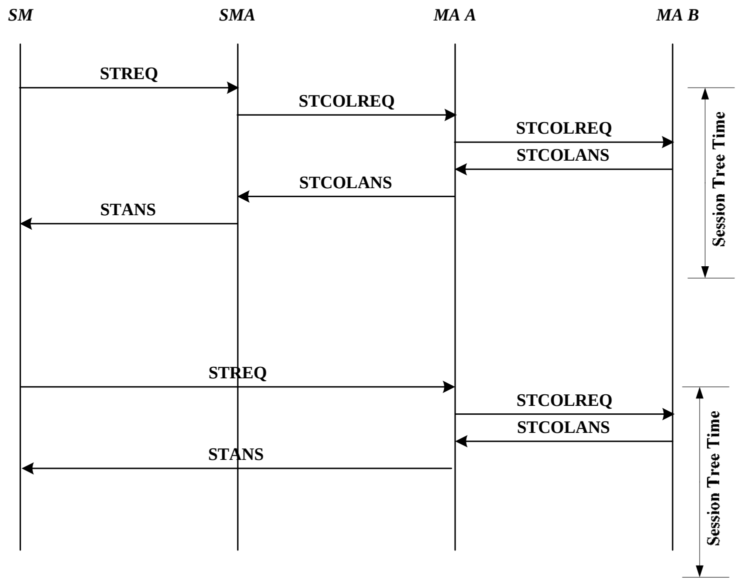

Figure 28 – Tree monitoring by collecting status report

7.2.5.3 Fault detection & recovery

This procedure is performed by each MA when each MA detects network faults and recovers from the problems to make the MMC-3 tree robust. Network faults such as looping or partitioning are often caused by an MA's frequent and careless movements. To detect and recover such network faults, MMC-3 provides the following fault detection and recovery mechanisms.

a) Loop detection and recovery

A loop can be detected by checking the ROOTPATH contained in HB. Because the ROOTPATH gives the path track from the SMA to itself, the duplicated hop in the ROOTPATH means that a loop has formed. Whenever a loop occurs, each MA performs the following loop recovery mechanism: for the scenario described in Figure 29, MA Y examines the HB; MA Y then confirms the existence of a loop whenever it receives HB_{n+3} because MA Z, which is a CMA of MA Y, is already listed in the ROOTPATH twice. To recover from the loop, MA Y sends MA Z a LEAVREQ message to disconnect.

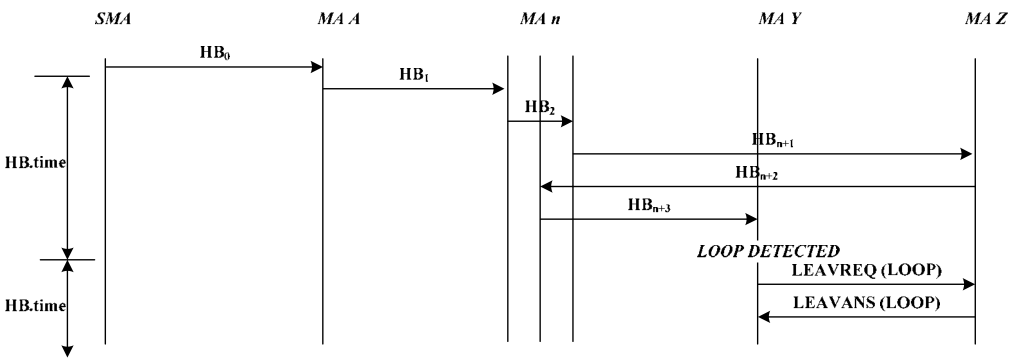

Figure 29 – Loop detection and recovery

b) Network partitioning detection and recovery

Whenever an MA fails to receive the HB message for a certain time, the MA assumes that it is partitioned from the tree. The time should be set for sufficient time to allow for a network delay. MMC-3 defines the time as HB_TIME × MAX_PARTITION_CNT.

A partition can occur whenever one of the partition's associates fails. The MA detects the source of the partitioning by contacting its associates; the MA then solves the problem. Figure 30 shows how MA Z detects tree partitioning: that is, a tree partition is detected whenever MA Z fails to receive the HB message for a certain period (HB_TIME × MAX_PARTITION_CNT). The failure to receive the HB message triggers the transmission of a number of PPROBREQ messages towards its associates. In Figure 30, MA Z receives a PPROBANS message from MA A and MA B but no response from MA C, the current PMA of MA Z. MA Z detects that the partitioning occurs as a result of the failure of the direct PMA of MA Z; MA Z then tries to switch parents in order to recover from the partitioning.

During an MA's repairing the partition, the MA's descendants may also consider that the network has partitioned and they may start to repair the partition. As a result, an MA's fails in just one point can cause an entire tree to collapse. To prevent from this problem, an MA, which is repairing a network fault, generates a pseudo HB message to its descendants to notify that the session is temporarily partitioned and being recovered.

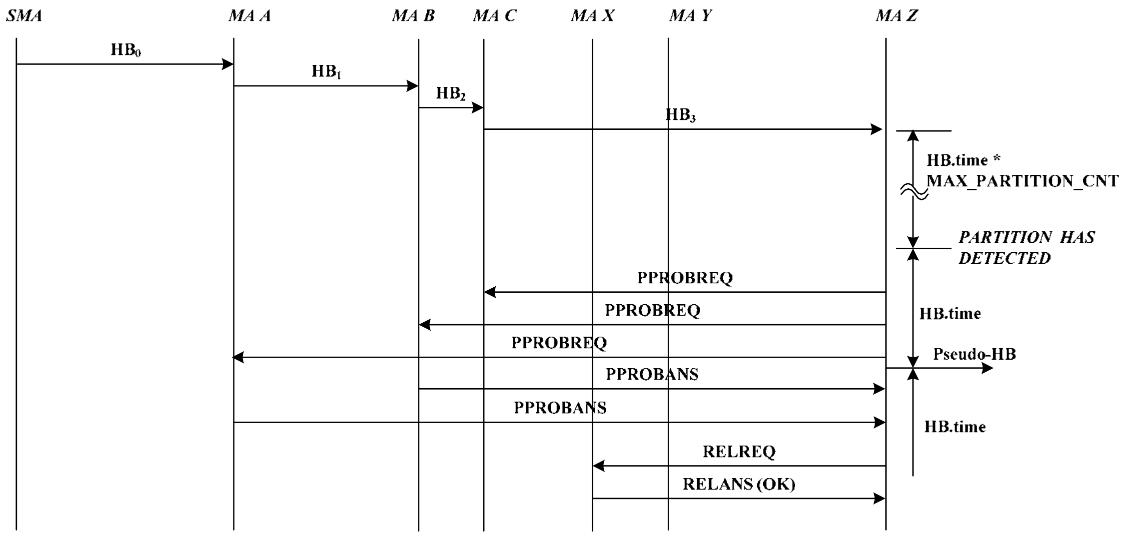

Figure 30 – Network partitioning detection and recovery

7.2.5.4 Tree improvement

Tree improvement procedure occurs when an MA finds one or more efficient PMA candidates and tries switching to the found one. By continuing the tree improvement procedure during the session, MMC-3 tree can be improved gradually.

The procedure for finding better nodes follows the neighbor discovery mechanism described in clause 7.2.2. At every turns of the neighbor discovery, each MA compares the QoS parameters of its current PMA with those of the newly discovered node. When an MA found a better MA than its current PMA, then the MA can switch its current PMA to a newly discovered MA according the parent switching procedure described in clause 7.2.4.2.

While the tree is being improved, network faults such as a loop or partition can easily occur. In particular, network faults may occur in the following cases: when multiple MAs in the same branch may try to switch their PMAs at the same time and when multiple MAs along the branch may try to successively switch their PMAs.

To keep a tree from these hazards, MMC-3 guarantees the atomic condition, in which each MA can switch a parent only after receiving a HB message with an unchanged ROOTPATH.

7.2.6 Termination

To terminate session, the SM sends a TERMREQ to SMA as shown in Figure 31. An SMA (or MA) that receives a TERMREQ message from the SM (or PMA) sends the TERMANS message back to the SM (or PMA) and then forwards the TERMREQ message to its CMAs until it reaches the end nodes of the tree. Finally, the session is closed.

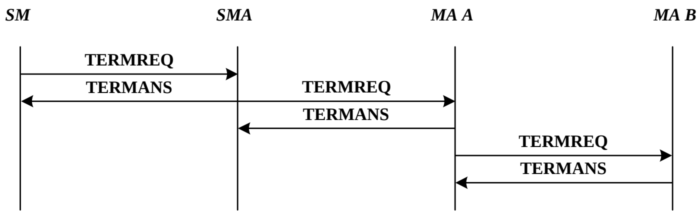

Figure 31 – Session Termination issued by SM

7.3 Mobile multicast agent's operation

Mobile multicast agent (MMA) is an MA with mobility support function for MN. MMA has the same function with MA along with additional function to support MN with mobility. This clause only describes mobility support function for MN. The other functions are equivalent to clause 7.2.

7.3.1 MMA announcement

The MN can exist anywhere in the network, so the MMA must inform the MN of its existence. The MMA broadcasts the mADVERTISE message to the wireless interface. The mADVERTISE message contains information that is needed by the MN such as, MMA information, control channel information (IP multicast address), servicing session. The mADVERTISE message is broadcasted every MMA advertisement time so that the MN would be aware of the MMA connectivity and join the multicast session anytime.

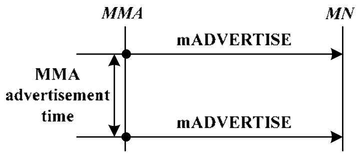

Figure 32 – MMA announcement

7.3.2 Support session join of MN

The MN can receive multicast service by registering to the MMA through mREGISTREQ message. After the MMA receives the mREGISTREQ from MN, the MMA must the register the MN in its local registry, and if needed, request SM for joining the multicast session through SUBSREQ message and join the session tree. If the MMA can provide multicast service to the MN, it informs the MA of the data channel (IP multicast address). The MN uses the data channel to receive multicast service. For efficient service, MMA may maintain the number of MNs which belongs to the MMA for specific session. If the number of MN for specific session equals to zero which means that there is no MN belonging to the MMA for the session, then the MMA should not broadcast the session data.

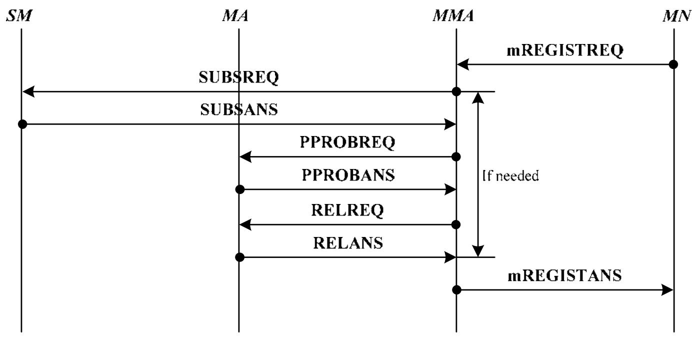

Figure 33 – Session join of MN

7.3.3 Support MN handover

When MMA received registration request (mREGISTREQ) from MN which has come from other network, the MMA should provide continous service to the MN. To achieve it, the MMA should subscribe the session requested by the MN. If the MMA is paricipating in the session, then it can broadcast the multicast data to the MN. Otherwise, the MMA requests session subscription with subscription request message (SUBSREQ) to SM. And then the MMA should inform the previous MMA of handover of the MN and join the session tree. By sending relay request message (RELREQ) to previous MMA, both purposes can be accomplished. To prevent rejection of relay request, urgent join control data could be used. The previous MMA acts as a PMA to the MMA in forwarding session data and recognizes the handover of the MN. After successful join to session tree, the MMA provides session data to the MN. The MMA would find better PMA performing parent probing procedure.

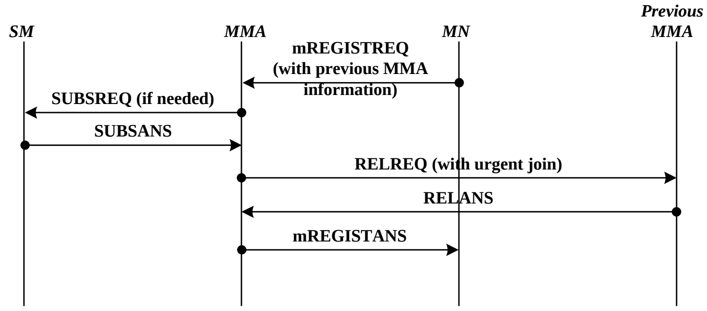

Figure 34 – Supporting MN handover

7.3.4 Data channel setting to prevent duplicated packet

If more than two MMA area overlaps, then MN might receive duplicated multicast packet from all the MMAs in the overlapped area. In order to prevent duplicated packet, MMA should use different data channel in broadcasting multicast packet to the wireless interface. That is, the two MMAs may use different multicast address for same session. The mechanism for differentiating multicast address between adjacent MMAs is not specified in this Recommandation.

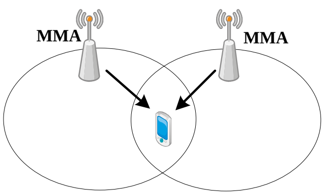

Figure 35 – Receiving duplicated packets

7.3.5 MN management

Each MMA maintain MN table to manage serving session. The MN table may consist of MNID, IP address of MN, connection status, registration request timer. MN can be used within both non-MMA region and MMA region. If MN is used within non-MMA region, MMA provides session data to MN through unicast; otherwise MMA provides session data to MN through multicast. Thus MMA should manage each MN differently. The connection status field is used for that purpose. Each record of the table is refleshed when MMA sends mREGISTANS message as response of mREGISTREQ message. If MMA does not receive the mREGISTREQ message from specific MN within registration request timer, MMA changes the MN's record status to "waiting for deletion". After waiting more N_WAIT_REG times, MMA removes the record from MN table.

7.4 Mobile Node's operation

7.4.1 Initiation

The Mobile node (MN) must go through the initiation process after a power on. The MN need to go through authentication and authorization process to get connection access to the network. After the network attachment, MN can subscribe to the MMC-3 session through SM. Before the initiation process, the MN needs the MMC-3 session information. The MMC-3 session information is announced by the MMC-3 service administrator through various methods, such as web-page, e-mail, etc. The user of the MN selects the multicast session and starts the MN initiation process.

The MN sends a SUBSREQ message to the SM to subscribe to the multicast session as shown in Figure 36. The SUBSREQ message contains information for the SM to decide whether to accept or reject the multicast session subscription request by the MN. In order to implement a manageable multicast service, the SM needs an authentication method to verify the MN and authorization method to approve of the MN's request. The decision rule for authentication and authorization is dependent on the service provider. Therefore, this Recommendation does not specify the precise SM's decision rule in accepting the new MN's subscription request.

Once the SM decides to accept the MN's session subscription, bootstrap information is given to the MN in the SUBSANS message which contains the result of the subscription and the active list of MMAs that the MN can receive the MMC-3 service. The list of MMA is needed in case the MN cannot find a local MMA that provide service to the wanted session. If the SM decides to reject the MN's session subscription, then it would also return the SUBSANS message containing the reason for rejection.

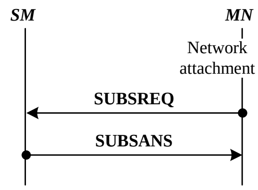

Figure 36 – Mobile Node subscription

After the successful subscription process, MN needs to find a MMA through MMA discovery procedure which is described in the next clause.

7.4.2 MMA discovery

After the initiation, MN needs to find a MMA. MMA may exist in the local network. MN sends an mSOLICIT message to the predefined multicast address given by the SM. MMA replies with a mADVERTISE message, if the MMA exists in the network as shown in Figure 37.

Figure 37 – MMA discovery procedure

If the MMA is not in the network, MN will not get a mADVERTISE reply. In this case, MN skips the MMA discovery procedure and performs the session join function in the following clause.

7.4.3 Session join

Session join procedure is for MN to join the MMC-3 session and receive MMC-3 multicast service. Figure 38 and Figure 39 shows procedure in MN joining the MMA.

7.4.3.1 Network with MMA

This procedure is for the session join of MN in the area with MMA. MN sends the mREGISTREQ message to MMA in multicast. If the MMA is not currently servicing the requested session, then it needs to join the session. The session join procedure of MMA is equivalent to procedure defined in clause 7.2.

If the MMA is ready providing the session, it sends a reply with mREGISTANS message. The flow for the session join in network with MMA is illustrated in Figure 38.

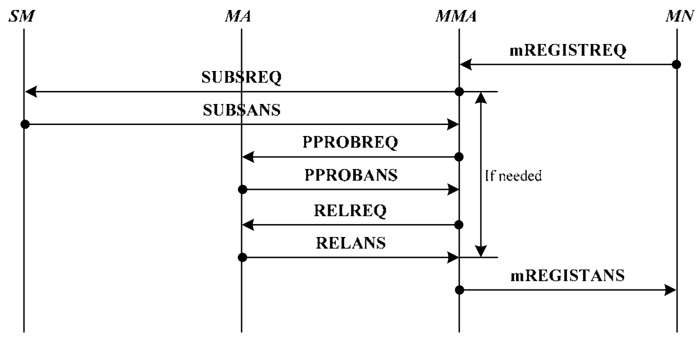

Figure 38 – Session join with MMA

After a successful join, MN and MMA exchange mREGISTREQ/mREGISTANS message periodically to maintain multicast session.

7.4.3.2 Network without MMA

This procedure is for the session join of MN in the area without MMA. Since there is no MMA in the local network, the MN must try to find an appropriate MMA that can provide MMC-3 service. The SM has given a list of MMAs in the SUBSANS message. Thus, MN can join with the MMC by requesting connection to each MMA in the list.

MN sends the RELREQ message to remote MMA in the list through unicast. If the remote MMA is unable to service the MN, then it will send a rejection in the RELANS with a reason.

If the remote MMA can support the MN, it will reply with a successful the RELANS message. The join procedure by the remote MMA is equivalent to procedure defined in clause 7.2.

If the MMA is ready providing the session service, it sends a reply with the RELANS message. The flow for the session join in network without MMA is illustrated in Figure 39.

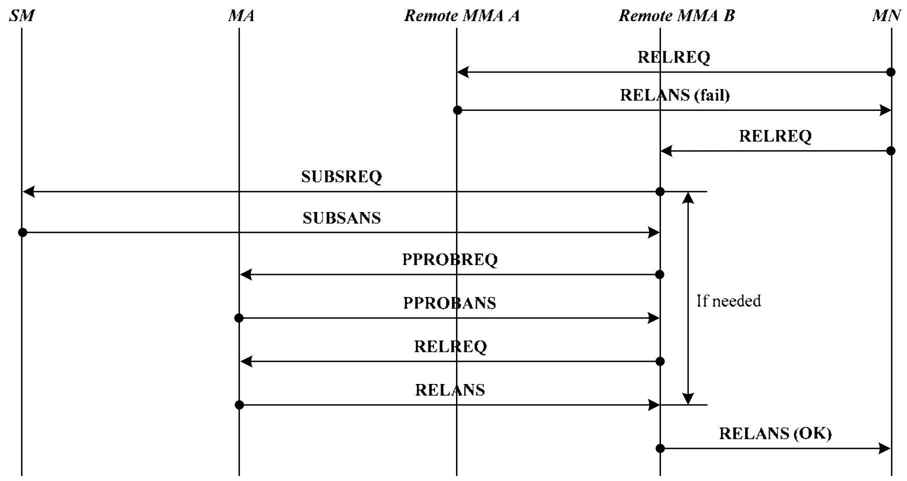

Figure 39 – MN Session join without MMA

After a successful join, MN and MMA exchange periodically the RELREQ/RELANS message to maintain multicast session.

7.4.4 Session leave

To leave MMC-3 session, MN just stops sending mREGISTREQ message to MMA. When MMA does not hear mREGISTREQ message from a specific MN for specific time period, then the MMA removes the MN status from its register. If the number of MNs for specific session equals to zero, then the MMA stops sending periodic RELREQ message for the session to its parent MA; as a result, the session data forwarding to the MMA is terminated.

If the leaving MN is in non-MMA region, the MN sends LEAVREQ message to the serving MMA. Upon receiving LEAVREQ message, the MMA removes the MN information from its register and reponds with LEAVANS. Receiving LEAVANS, the MN leaves the session promptly.

7.4.5 Handover

Handover procedure is for MN to switch its MMA when the MN moves to other mobile network. The handover procedure can be defined in two approaches. The first approach is to define handover for movement to MMA area, the second approach is movement to non-MMA area.

7.4.5.1 MN movement to MMA area

When MN, which is served by old MMA, moves into a new mobile network which is managed by new MMA, the MN perceives that it is time to change its MMA. MN can perceive movement by receiving mADVERTISE message from new MMA or by disconnection with the old MMA.

When MN founds a new MMA, MN tries to join with the new MMA by sending mREGISTREQ message. New MMA which receives MN's registration request subscribes to requested MMC-3 session by exchanging subscription messages with SM.

After the new MMA's successful attachment, MN receives mREGISTANS message of successful registration; then the MN receives data from new MMA but refuses the data from old MMA.

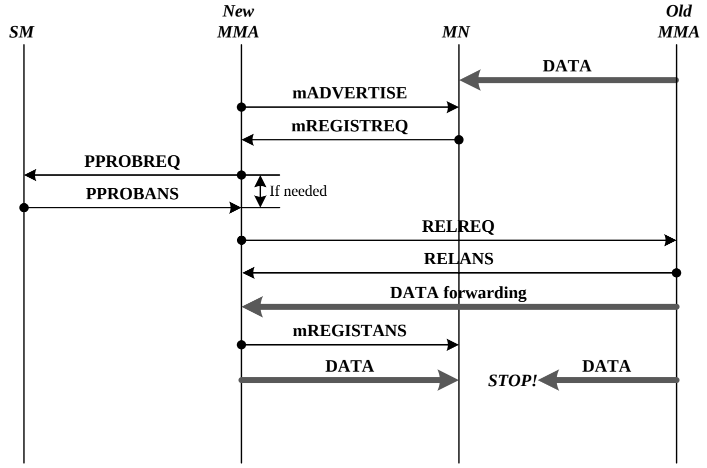

Figure 40 – Handover procedure in MMA area

7.4.5.2 MN movement to non-MMA area

MN can move to non-MMA region. The MN will notice that the data it should be receiving is lost and find no reply to the mSOLICIT message. The MN will know that it has move to the area without MMA.

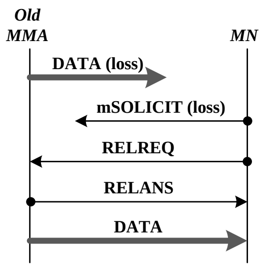

Figure 41 – Handover procedure in non-MMA area

MN sends a RELREQ message to the old MMA. The old MMA answers with the RELANS. If the old MMA lacks resource in forwarding data to the MN, then it will reply with a failure message. In that case, the MN has to start the session join with the new MMAs in the list of MMAs given by the SM. If the old MMA can provide MMC-3 service, then it will forward the multicast data to the MN.

7.4.6 Session termination

The MMC-3 session can terminate. The session termination is initiated by the SM. Figure 42 shows the procedure of session termination. The SM sends TERMREQ message to the MA in the MMC-3 tree. If the MA receives a TERMREQ message, it sends TERMANS message back to SM and then forwards TERMREQ message to child MA which can be MA or MMA. All nodes in the MMC-3 session must terminate the MMC-3 session upon reception of TERMREQ message. The MN does not send TERMANS message as response of TERMREQ message because lots of TERMANS from MNs can make congestion in wireless network.

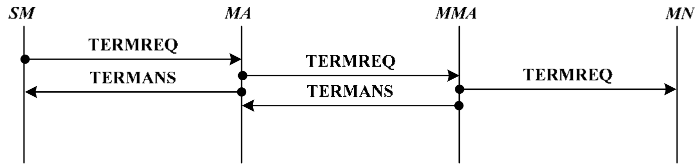

Figure 42 – Session termination procedure

8 Messages

Editor's Note*: This section includes messages considered in MMC-3;*

Editor's Note*: Better to use the name of protocol instead of project name (MMC-3); better to use different protocol name differently from project name or invent a new protocol name for the MMC-3. The name to satisfy MMC-3 will be proposed in next meeting.*

8.1 Common format of MMC-3 message

TBD

8.1.1 Control message format

TBD

Control data format

TBD

8.2 MMC-3 Messages Control message

This chapter defines each message used in MMC-3. MMC-3 defines seven sets of *request and reply* manner (sometimes called as *request and confirm* manner) of messages and one heartbeat message.

8.2.1 mADVERTISE

This message is used by MA to advertise its existence to mobile nodes; the nodes can be existed or newly arrived one.

Ver (0x04)	NT (MMA)	Message Type (mADVERTISE)	Length (Variable)
Session ID (NULL)			
MAID			
Control Data (SYS_INFO, TIMESTAMP, GROUP_INFO, LIFETIME,CONTROL_CHANNEL)			

Figure 43 – mADVERTISE

8.2.2 mSOLICIT

This message is used by mobile node to solicit any possible MA in newly visited network; the node already existed can use this message when an announcement from MA has not arrived for a specific time.

Ver (0x04)	NT (Mobile Host)	Message Type (mSOLICIT)	Length (Variable)
Session ID (NULL)			
Mobile Host ID (Mobile Host's IPv4 Address(HoA) + Port Number + SSN)			
Control Data			

Figure 44 – mSOLICIT

8.2.3 mREGISTREQ

This message is used by mobile node to register itself to MA.

Ver (0x04)	NT (Mobile Host)	Message Type (mREGISTREQ)	Length (Variable)
Session ID			
Mobile Host ID			
Control Data (LIFETIME, OMA_INFO, IDENTIFICATION)			

Figure 45 – mREGISTREQ

8.2.4 mREGISTANS

This message is used by MA to confirm that MA has registered mobile node.

Ver (0x04)	NT (MMA)	Message Type (mREGISTANS)	Length (Variable)
Session ID			
MAID			
Control Data (IDENTIFICATION, DATA_CHANNEL, RESULT)			

Figure 46 – mREGISTANS

8.2.5 RELREQ

This message is used by the CMA to request to the PMA of data forwarding. It usually includes a data profile which can be negotiated through the message exchanges of RELREQ and RELANS. Figure 47 depicts the format of this message. The followings are the descriptions and information of each field.

This message is also used to process urgent join and leave forwarding to handle mobile node between MAs.

Ver (0x04)	NT (MMA)	Message Type (RELREQ)	Length (Variable)
Session ID			
MAID			
Control Data (URGENT_JOIN, LEAV_FORWARD, PMA_INFO, COMMAND)			

Figure 47 – RELREQ

8.3 MMC-3 Control data

8.3.1 GROUP_INFO

This control message is to provide session information to mobile nodes.

Control type (GROUP_INFO)	Length (variable)	Group Count
Group Address [1]		
Service Type [1]		
Group Address [n]		
Service Type [n]		

Figure 48 – GROUP_INFO

(a) *Control_type* - GROUP_INFO

(b) *Length* - total length

(c) *Group Count* - number of session in service

(d) *Group Address [1]~[n]* - session Class D address in service

(e) *Service Type [1]~[n]* - session information (stored in char)

8.3.2 LIFETIME

This control message is to register time between terminal and MA. And this control message is used for mADVERTISE and mREGISTREQ messages.

Control type (LIFETIME)	Length	Timeval (Sec)

Figure 49 – LIFETIME

(a) Control_type - LIFETIME

(b) Length - total length

(c) Group Count - maximum register time or request time (Second)

8.3.3 OMA_INFO

This control message is to request its leave through new MA to old MA. And this control message is used for mREGISTREQ message.

Control type (OMA_INFO)	Length	reserved
OMA Address		

Figure 50 – OMA_INFO

(a) Control_type - OMA_INFO

(b) Length - total length

(c) OMA Address - OMA IP address

8.3.4 IDENTIFICATION

This control message is to request its registration and to acknowledge message authentication. And this control message is used for mREGISTREQ and mREGISTANS messages.

Control type (IDENTIFICATION)	Length	reserved
Identification Code (64)		

Figure 51 – IDENTIFICATION

(a) Control_type - IDENTIFICATION

(b) Length - total length

(c) Identification Code - 64bit

8.3.5 Control Channel / Data Channel

This control message is to give information on channel for control and data. And this control message is used for mADVERTISE message.

Control type (DATA_CHANNEL/ CONTROL_CHANNEL)	Length	Reserved
Channel Address (32)		

Figure 52 – CONTROL_DATA_CHANNEL

(a) Control_type - IDENTIFICATION

(b) Length - total length

(c) Channel Address - 32bit Class D group address

8.3.6 URGENT_JOIN

This control message is used by new MA to attach to mobile node's old MA for seamless data forwarding. This type of join is necessary for MA to save time from attaching parent MA. And this control message is used for RELREQ message.

Control type (URGENT_JOIN)	Length	Reason

Figure 53 – URGENT_JOIN

(a) Control_type - URGENT_JOIN

(b) Length - total length

(c) Reason - Urgent_join reason

8.3.7 LEAV_FORWARD

This control message is used by new MA to tell its mobile node's leave to the leaving mobile node's old MA. This type of leave forward is necessary when the forwarding path is constructed according to the MA's trail; it is necessary to delete the constructed path by a leaving MA. And this control message is used for RELREQ message.

Control type (LEAV_FORWARD)	Length	reserved
Mobile Host ID		

Figure 54 - LEAVE_FORRWARD

(a) Control_type - LEAV_FORWARD

(b) Length - total length

(c) Mobile Host ID - leave requested Mobile Host ID

9 Parameters

Editor's Note*: This section includes parameters considered in MMC-3;*

TBD

10 Security

Editor's Note*: This section will deal with security issues of MMC-3. Security issues to be considered may include;*

TBD