International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

X.604.1

(03/2010)

SERIES X: DATA NETWORKS, OPEN SYSTEM COMMUNICATIONS AND SECURITY

OSI networking and system aspects – Networking

Information technology – Mobile multicast communications: Protocol over native IP multicast networks

Recommendation ITU-T X.604.1

ITU-T

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INTERNATIONAL STANDARD ISO/IEC 24793-2
RECOMMENDATION ITU-T X.604.1

Information technology – Mobile multicast communications: protocol over native IP multicast networks

Summary

Recommendation ITU-T X.604.1 | ISO/IEC 24793-2 describes the mobile multicast control protocol (MMCP) for mobile multicast communications over native IP multicast networks. This Recommendation | International Standard describes the specification of the MMCP protocol, which includes design considerations, protocol operations and packet format.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T X.604.1	2010-03-01	11

Keywords

IP multicasting, mobile multicast communication, mobile multicast control protocol.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

CONTENTS

Introduction

The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

Rec. ITU-T X.604.x | ISO/IEC 24793 consists of the following parts, under the general title of: Information technology – Mobile multicast communications:

- Part 1: Framework (Rec. ITU-T X.604 | ISO/IEC 24793-1, MMC-1)
- Part 2: Protocol over native IP multicast networks (Rec. ITU-T X.604.1 | ISO/IEC 24793-2, MMC-2)
- Part 3: Protocol over overlay multicast networks (Rec. ITU-T X.604.2 | ISO/IEC 24793-3, MMC-3)

INTERNATIONAL STANDARD

RECOMMENDATION ITU-T

Information technology – Mobile multicast communications: protocol over native IP multicast networks

1 Scope

This Recommendation | International Standard describes the specification of mobile multicast control protocol (MMCP) over native IP multicast networks for mobile multicast communications. The MMCP can be used to support a variety of multimedia multicasting services in the IP-based wireless mobile networks. The MMC is targeted at the real-time one-to-many multicast services and applications over mobile communications networks. This Recommendation | International Standard describes the procedures and packet formats of the MMCP protocol.

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.

– Recommendation ITU-T X.604 (2010) | ISO/IEC 24793-1:2010, *Information technology – Mobile multicast communications: Framework*.

3 Definitions

This Recommendation | International Standard uses the terms and definitions that are defined in the MMC framework, Rec. ITU-T X.604 | ISO/IEC 24793-1.

4 Abbreviations

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

AAA	Authentication, Authorization and Accounting
ACK	Acknowledgement
ASR	Aggregation Status Report
CTT	Context Transfer Time
HCT	Handover Context Transfer
HIC	Handover Initiation Confirm
HIR	Handover Initiation Request
HIT	Handover Initiation Time
HTA	Handover Transfer ACK
ID	Identifier
IGMP	Internet Group Management Protocol
JWT	Join Waiting Time
LJC	Local Join Confirm
LJR	Local Join Request
LMC	Local Mobility Controller
MCS	Multicast Contents Server
MLD	Multicast Listener Discovery

MMC	Mobile Multicast Communications
MMCF	MMC Framework
MMCP	Mobile Multicast Control Protocol
MN	Mobile Node
MR	Multicast Router
PoA	Point of Attachment
QoS	Quality of Service
SJC	Session Join Confirm
SJR	Session Join Request
SM	Session Manager
SPT	Status Probe Time
SRT	Status Report Time
TLV	Type-Length-Value
ULC	User Leave Confirm
ULR	User Leave Request
USP	User Status Probe
USR	User Status Report

5 Overview

The MMCP provides the control functionality for multicast data channels: Session Join, Status Monitoring and Handover Support. A multicast data session consists of an MCS (sender) and many MNs (receivers). The MCS will transmit multicast data packets to many prospective receivers, according to a predetermined program schedule. To receive the multicast data in the network, an MN will first perform the IGMP/MLD operations with the corresponding access router in the IP subnet. The MMCP can be used for control of multicast sessions together with any multicast data channels. The details of multicast data transport mechanisms are outside the scope of MMCP.

For Session Join, a prospective MN shall send a session join request message to the MMCP session manager (SM). The join request message shall include the following information: Session ID and MN ID. MN ID is an identifier allocated to the MN, which may be given *a priori* by a services provider. On receipt of the session join request message, the SM shall respond to the MN with a session join confirm message. The responding confirmation message will indicate whether the join request is accepted or not. In case that a local mobility controller (LMC) is allocated to the MN, the session join confirm message will also contain the contact information of the associated LMC. In case that an LMC is assigned to the MN, after receiving the join confirm message, the MN shall also join the designated LMC by sending a local join request message. On receipt of the local join request message, the LMC shall respond to the MN with a local join confirm message.

For User Leave, during the multicast session, an MN may want to leave the session. For this purpose, the MN may send a user leave request message to the LMC (in case that an LMC is assigned to the MN) or to the SM (in case that no LMC is assigned to the MN). The LMC (or SM) may respond to the MN with the user leave confirm message. It is noted that this user leave operation is optional. That is, a certain MN may leave the session without any notice.

Status Monitoring is used by the SM to monitor the dynamics for group/session membership and the status of multicast data channel (e.g., statistics such as total number of packets received during the session). For status monitoring, each MN shall send a periodic status report message to its upstream LMC or SM (in case that no LMC is assigned to the MN). Each LMC will aggregate the status information for its downstream MNs, and send a periodic aggregate status report message to the SM. In the meantime, the status report messages may be lost in the network. In this case, the upstream LMC or SM may solicit a status report message to the concerned MN or LMC by sending a status probe message.

For Handover Support, after movement detection, the MN begins the handover operations by sending a handover request message to the current LMC. The handover request message shall include the information about the new point of attachment (PoA) such as the link-layer MAC address or ID of the PoA. On receipt of a handover request message from the MN, the LMC will first identify which subnet the MN is going to move into. The current LMC can identify the new LMC by using the address of the ID of the new PoA that is indicated in the handover request message. For handover support, the current LMC shall send a handover context transfer message to the new LMC. Then, the new LMC will perform the IGMP/MLD join operation to the new MR, instead of the MN. This will ensure that the MN can receive the multicast data packets in the newly visited subnet as fast as possible. After that, the new LMC will respond to the current LMC with a handover transfer ACK message. In turn, the current LMC will send a handover confirm message to the MN. This will complete the handover operation of the MMCP. After further movement, the MN will complete the establishment of a new L2 and L3 connection (for a new IP address of the MN). Then, the MN performs the local join operations with the new LMC.

6 Considerations

6.1 Protocol model

The MMCP is based on the mobile multicast communications framework (MMCF) specified in Rec. ITU-T X.604 | ISO/IEC 24793-1. The MMCP is designed to support one-to-many real-time multicast applications running over IP multicast-capable wireless/mobile networks. MMCP operates over IPv4/IPv6 networks with the IP multicast forwarding capability such as the IGMP/MLD and IP multicast routing protocols. As a control protocol, the MMCP provides a mobile user with the session join and user leave, status monitoring, and handover support for multicast data channels.

The MMCP is a control protocol that is used for control of the mobile multicast sessions over native IP multicast mobile/wireless networks. It is assumed that the multicast data channels are provided with the help of the UDP/IP multicasting in the network. That is, the MMCP is independent of multicast data channels, as depicted in Figure 1.

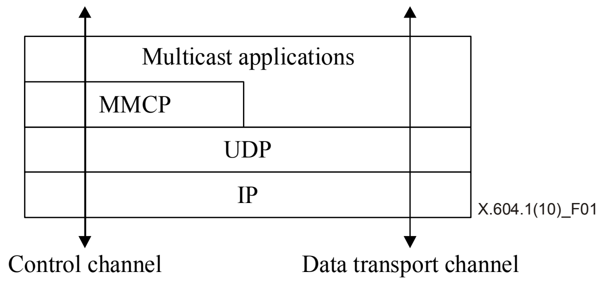

Figure 1 – Protocol model

A multicast data channel can use the MMCP protocol for the control of multicast sessions. For this purpose, the MMCP provides a set of application programming interfaces (APIs) for any multicast data channels/applications. In the protocol stack point of view, an MMCP message is encapsulated into the UDP datagram.

6.2 Protocol entities

This clause describes the protocol entities associated with the MMCP.

6.2.1 Mobile node (MN)

An MN represents an end user that receives multicast data transport services from multicast contents server. To receive the multicast data from the network, the MN should be equipped with the multicast capability such as the IGMP/MLD protocol. The MN is also required for the MMCP functionality. With the help of MMCP, an MN can benefit from the control services such as session join, status monitoring, and handover support.

6.2.2 Multicast contents server (MCS)

In MMCP, an MCS represents the sender of the multicast data channel/session. The MCS will continue to transmit the multicast data streams over the network, and a lot of MNs will receive the data packets after session join. The MCS is associated with the multicast data channel only rather than the MMCP control channel. The MCS could exchange some session-related information with the MMCP session manager, possibly using a dedicated communication channel, which is outside the scope of this Specification.

6.2.3 Session manager (SM)

The SM is responsible for the overall operations of the MMCP. In Session Join, the SM will respond to the join request of a promising MN. For authentication, the SM may contact with an AAA-related database or user profile that has been preconfigured by services provider, which is outside the scope of the MMCP. In Status Monitoring, the SM will monitor the overall status of the membership and session for all of the MNs. For this purpose, each MN will send periodic control messages to the SM, possibly by way of a local mobility controller. The SM may be implemented with the MCS on the same system, which is an implementation issue.

6.2.4 Local mobility controller (LMC)

The LMC is used to locally control the movement of the MN. In the mobile wireless networks, when an MN moves into the other network region during the multicast session, the handover support is required for seamless multicast services. The LMC is used to support the seamless handover for the MN in the wireless/mobile networks.

For handover support, the movement of the MN will be informed to the associated LMC. To provide the seamless services, an LMC may interact with other LMCs that are newly visited in the network by the MN. With the help of the LMC, an MN can be given seamless multicast services against handover. The LMC is also used for status monitoring of the MNs. Each MN will send a periodic message to LMC, and the LMC aggregates the status of its downstream MNs and forwards the aggregated status information to the SM. It is noted that an LMC acts as a network agent for MNs in the MMCP.

It is assumed that a set of LMCs have been deployed in the wireless networks by the services provider.

6.3 Reference network configuration

Figure 2 shows a reference configuration of the MMCP entities in the network.

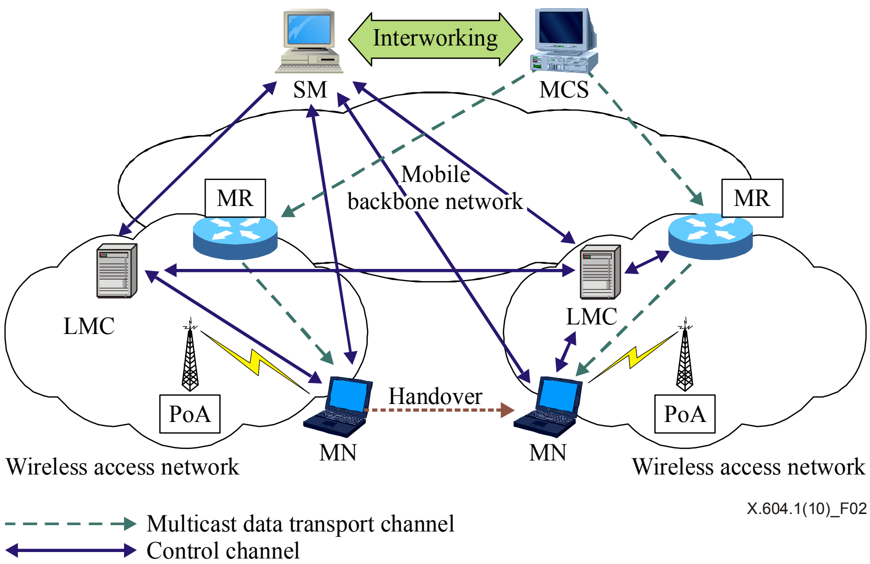

Figure 2 – Configuration of MMCP protocol entities

As shown in the figure, the multicast data channels operate between the MCS and the MNs with the help of multicast routers (MRs) and point of attachments (PoAs) in the network. The MMCP operates independently of the data channels. The MMCP operations are performed between the SM and the LMC, between the SM and the MN, and between the LMC and the MN.

It is assumed that an LMC is located within the IP subnet controlled by an MR. For effective handover support, an LMC needs to operate in the same IP subnet with the concerned MNs. In a certain case, an LMC may be implemented with an MR over the same equipment, which is a deployment issue.

For mobility support, an MN detecting its movement will inform the LMC for mobility control. The MN's movement types include the change of PoA (at the link layer) or MR (IP layer). The information on such movement shall be used to support seamless handover by LMCs, in which the LMCs will interwork with each other and the new LMC interacts with the corresponding MR.

6.4 Messages

The protocol messages used for MMCP are summarized in Table 1.

Table 1 – Messages used in MMCP protocol

Message name	Acronym	Type value	From	To
Session Join Request	SJR	0000 0001	MN	SM
Session Join Confirm	SJC	0000 0010	SM	MN
Local Join Request	LJR	0000 0011	MN	LMC
Local Join Confirm	LJC	0000 0100	LMC	MN
User Leave Request	ULR	0000 0101	MN	LMC or SM
User Leave Confirm	ULC	0000 0110	LMC or SM	MN
User Status Report	USR	0000 0111	MN	LMC or SM
Aggregation Status Report	ASR	0000 1000	LMC	SM
User Status Probe	USP	0000 1001	LMC	MN
			SM	LMC or MN
Handover Initiation Request	HIR	0000 1010	MN	LMC or SM
Handover Context Transfer	HCT	0000 1011	Old LMC	New LMC
Handover Transfer ACK	HTA	0000 1100	New LMC	Old LMC
Handover Initiation Confirm	HIC	0000 1101	LMC or SM	MN

As described in the table, SJR and SJC are used for session join to the SM. LJR and LJC messages are used for local join to the LMC. ULR and ULC are for user leave. The USR, ASR, and USP messages are used for status monitoring during session. On the other hand, HIR, HCT, HTA, and HIC messages are used for handover support.

7 Procedures

7.1 Multicast data transport

The MCS will transmit multicast data packets to many prospective receivers, according to a predetermined program schedule, as shown in the IPTV electronic program guide. The multicast data packets transmitted by an MCS will be delivered toward many MNs over IP multicast networks with the help of the multicast routing protocols such as source specific multicast (SSM) or protocol independent multicast (PIM), etc.

After session join, an MN can receive the multicast data packets from the MCS. The MN may be allowed to receive the multicast data only after an appropriate authentication/authorization process with the SM, which is done in the Session Join operation. To receive the multicast data in the network, an MN will first perform the IGMP/MLD operations with the corresponding access router in the IP subnet.

The MMCP can be used for the control of multicast sessions together with any multicast data channel. The details of multicast data transport mechanisms are outside the scope of MMCP.

7.2 Session join

Session join is the operation for MN to join a multicast session, as depicted in Figure 3.

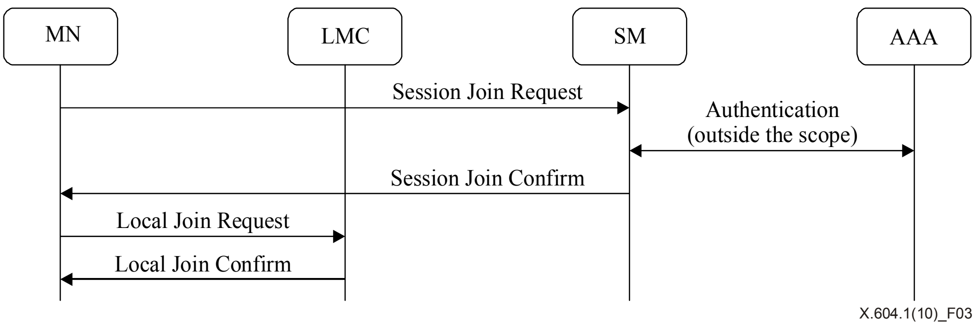

Figure 3 – Session join and local join

To join a session, a prospective MN shall send the SJR message to the SM. The SJR message shall include the following information: Session ID and MN ID. It is assumed that the Session ID has already been informed to the prospective MNs by using a different mechanism such as a web announcement. It is noted that the IP address and port number of the SM will also be announced to the prospective MNs, which will ensure that the MN can send an SJR message to the associated SM. The MN ID is an identifier allocated to the MN, which may be given by a services provider associated with the multicast services. The SJR message can also include the information of the PoA attached to the MN, which may be used for the SM to determine the best LMC for the MN.

On receipt of the SJR message, the SM shall respond to the MN with an SJC message. For this purpose, the SM may first check whether the MN is an authenticated/authorized user by contacting with an associated AAA server, which is outside the scope of the MMCP. The responding SJC message will indicate that the join request is accepted or not by using a flag bit of the message. In the successful case, the SJC message shall include the information about the corresponding multicast data channel: IP multicast address and port number. In case that an LMC is allocated to the MN, the SJC message will also contain the IP address and port number of the associated LMC.

In the MN point of view, after sending the SJR message, the MN will wait for the responding SJC message for the join waiting time (JWT). If the SJC message does not arrive at the MN during the JWT time, the MN concludes that the join request has failed. The associated indication may be delivered to the upper-layer application, which is an implementation issue.

In case that an LMC is assigned to the MN, after receiving the SJC message, the MN shall send an LJR message to the indicated LMC. The LJR message shall include the MN ID. On receipt of the LJR message, the LMC shall respond to the MN with an LJC message. The responding LJC message shall indicate that the local join request is accepted or not.

In the MN point of view, after sending the LJR message, the MN will wait for the responding LJC message for the join waiting time (JWT). If the LJC message does not arrive at the MN during the JWT time, the MN concludes that the local join request has failed. The associated indication may be delivered to the upper-layer application, which is an implementation issue.

7.3 User leave

During the multicast session, an MN may want to leave the session. For this purpose, the MN may send a ULR message to the LMC (in case that an LMC is assigned to the MN) or to the SM (in case that no LMC is assigned to the MN). The LMC (or SM) may respond to the MN with the ULC message. In this case, the LMC may send an ASR message to the SM so as to inform the changed group membership for the session. The User Leave operation is shown in Figure 4.

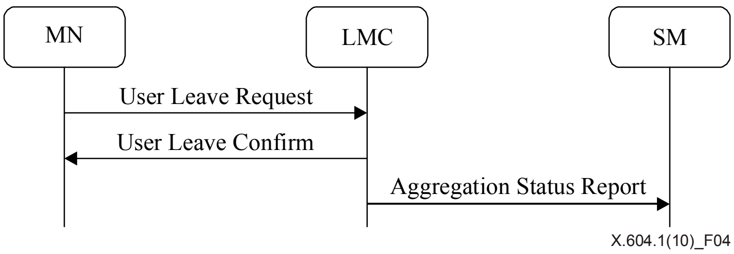

Figure 4 – User leave

It is noted that this User Leave operation is optional. That is, a certain MN may leave the session without any notice to its upstream LMC or SM. For example, an abnormal disconnection of the network may occur before the user leave operation. In this case, the information of the user leave will be detected by the upstream node via the subsequent Status Monitoring operations.

7.4 Status monitoring

Status monitoring is used to monitor the group membership of the session and the statistical status of the multicast data channel. In Status Monitoring, each MN shall send a periodic USR message to its upstream LMC or SM (in case that no LMC is assigned to the MN). Each LMC will aggregate the status information of its downstream MNs, and send a periodic ASR message to the SM. Figure 5 shows the normal status monitoring operations in MMCP.

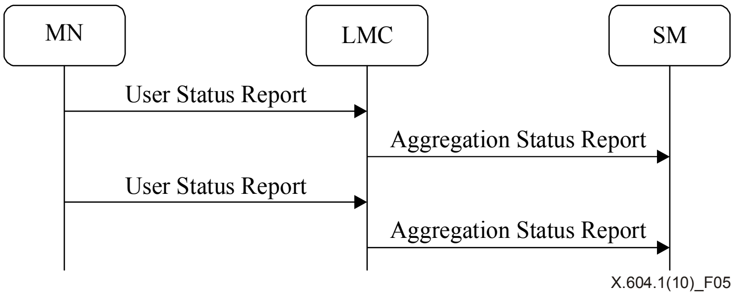

Figure 5 – User status report

While a session is active, each MN shall send a USR message to its upstream node for every status report time (SRT). The SRT value may be locally configured. The USR will contain the information about the MN ID and the measured statistics for multicast data channel such as the number of totally received packets and the elapsed time in the session. To get the status of the data channel, the MMCP control channel may need to interact with the multicast data channel. Such a detailed mechanism is outside the scope of the MMCP.

The LMC shall aggregate all of the status information from its downstream MNs, and it shall also send a periodic ASR message to the SM according to its own SRT timer. The ASR message includes the status information of its downstream MNs.

Depending on the network condition, a USR or ASR message may be lost in the network. In this case, the upstream node will request the status report message to the concerned downstream node by sending a USP message, as shown in Figure 6.

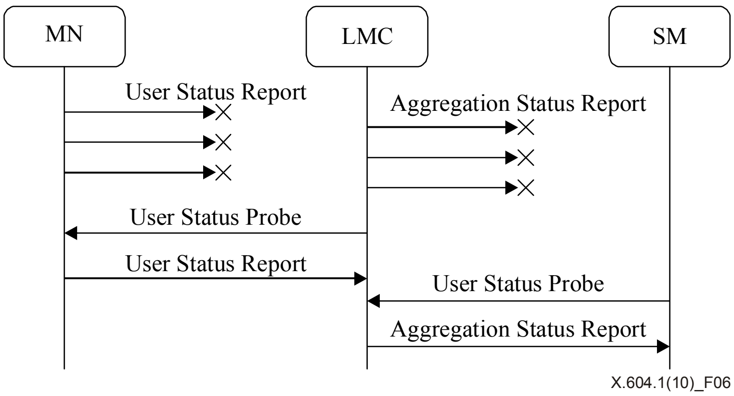

Figure 6 – User status probe

As shown in the figure, when an upstream LMC has not received any USR message from an MN for the preconfigured status probe time (SPT), it shall send a USP message to the concerned MN. The SPT value may typically be set to '3 x SRT'. The MN shall respond to its upstream LMC with the USR message, as soon as it receives a USP message. In a similar way, the SM may send a USP message to its downstream LMCs for status monitoring.

Nevertheless, a certain MN may not respond with a USR message in the viewpoint of LMC. In this case, the LMC will send another USP message again every SPT time. If an MN has not responded to three consecutive USP messages, it will be detected as a failed MN by the LMC. In a similar way, the SM detects a failure of its downstream LMC.

7.5 Handover support

The handover support is the key feature of MMCP. The MMCP provides handover support for the MN in the mobile multicast communications.

As already described in Figure 2 of clause 6.3, there are one or more PoAs in the subnet controlled by the multicast router (MR). When an MN moves within the same IP subnet, the IP handover for multicasting will not be required. In this case, only the link-layer handover (by change of PoA) will be performed, which is outside the scope of this Specification. The MMCP considers the handover scenario in which the MN moves into a new IP subnet and thus changes its associated MR as well as PoA.

Figure 7 shows an overview of handover control operations between the MN and the LMC. It is assumed that there is one LMC in each IP subnet associated with an MR. In the figure, the information flows indicated by the solid lines are associated with MMCP, whereas the dotted lines represent the other relevant processing flows.

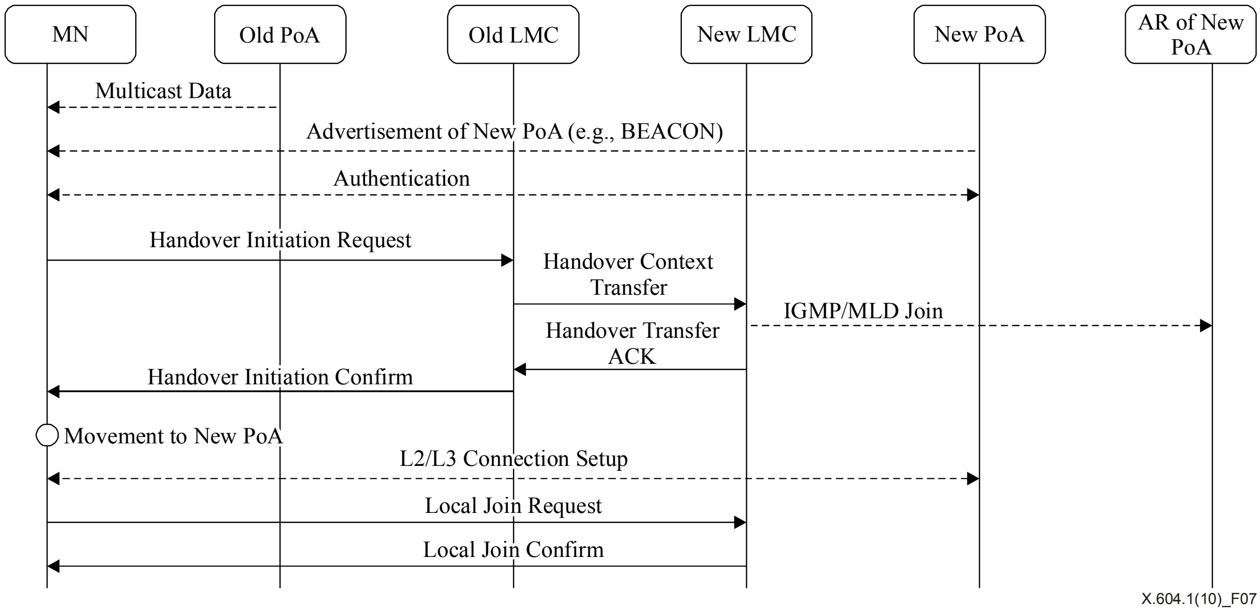

Figure 7 – Handover support

In the figure, an MN is receiving multicast data packets in an MR region via the old PoA. By handover, the MN now moves into another MR region and gets a link-layer trigger for the new PoA, which may be performed with the help of the advertisement messages of the new PoA (e.g., BEACON message of AP in the WLAN network, or pilot channel of Base station in the 3G wireless network). This is called 'movement detection'. Then an appropriate authentication process may be performed, which is specific to the underlying wireless access system.

In the viewpoint of MMCP, after the movement detection, the MN begins the handover operations by sending an HIR message to the old LMC. The HIR message shall include the information about the new PoA (e.g., link-layer MAC address or ID of PoA such as Line ID, BSSID of AP, etc.).

On receipt of an HIR message from the MN, the LMC will identify which subnet the MN is going to move into. The old LMC can identify the new LMC by using the address of ID of the new PoA which is contained in the HIR message. It is noted that the LMCs in MMCP are pre-deployed and preconfigured by the corresponding services provider. Accordingly, it is assumed that each LMC will share all the information with other LMCs. The examples of the contact information include the MAC and IP address of LMC, and also the MAC addresses and IDs for the PoAs associated with each LMC.

Based on the information described above, the old LMC shall send a HCT message to the new LMC. The HCT message shall include the information about the ID of the MN and the group address used for the multicast data channel.

On receipt of an HCT message, the new LMC will perform the IGMP/MLD join operation to the new MR as an agent of the MN. This is done for the MN to receive the multicast data packets in the newly visited subnet as soon as possible. After that, the new LMC will respond to the old LMC with the HTA message. In turn, the old LMC will send an HIC message to the MN. This will complete the handover operation for mobile multicasting.

After further movement toward the new PoA, the MN will complete the layer 2 (L2) and layer 3 (L3) movement. By this, the MN will establish the new L2 and L3 connection (with a new IP address of MN). Then the MN performs the session join and local join operations, as described in clause 7.2.

For reliable transmission of MMCP messages for handover support, the handover initiation time (HIT) timer is used by the MN for the HIR and the HIC messages, and the context transfer time (CTT) timer is used by the old LMC for HCT and HTA messages. After sending an HIR message to the old LMC, the MN waits for the responding HIC message for HIT time. The MN will retransmit the HIR message to the old LMC, if there is no responding HIC message before the HIT timer expires. In a similar way, after sending an HCT message to the new LMC, the old LMC will wait for the responding HTA message from the new LMC for CTT time. The HIT and CTT timers may be locally configured by the MN and the LMC.

It is noted that the handover support of MMCP can be applied to the horizontal handover (handover between homogeneous access networks, e.g., between PoAs within the 3G wireless networks) as well as the vertical handover (between heterogeneous access networks, e.g., between 3G wireless and mobile WiMax). In case of vertical handover, an MN is equipped with the two different types of network interfaces. In this case, the detection of a new PoA and the MMCP handover operations can be easily performed since the MN could be connected to both of access networks (including the concerned two PoAs and two MRs) in the overlapping region. In case of horizontal handover, the MMCP handover operations need to use an appropriate link-layer trigger such as Link-Up or Link-Down event, which are addressed in the IEEE 802.21 MIH (media independent handover). With the help of such a link-layer trigger, the MN can detect its movement to a new link or network, and it can begin the handover support operations by sending the HIR message to the old LMC.

In the MMCP handover, the handover performance, such as packet loss and handover latency during handover, might depend on several factors which include the overlapping time interval in the handover region and the underlying link layer technology. For example, when the overlapping time interval in the handover region is large enough to complete the handover operations, the MN could benefit from seamless services during handover. Otherwise, the MN might experience a certain amount of packet losses during handover. In case of horizontal handover, if the underlying link layer supports a soft handover, the handover performance for the MN can be more enhanced. Further issues on handover performance are outside the scope of MMCP.

8 Packets

8.1 Packet format and common header

An MMCP packet consists of the 8-byte common header and the variable-length parameters, as shown in Figure 8. As per the type of packet, zero or more parameters can be added to the common header.

Common Header (8-byte)	Parameters (Variable Length)

Figure 8 – MMCP packet structure

The 8-byte common header contains the information commonly referred to by all of the MMCP packets, which include packet type, total length and session ID, as shown in Figure 9.

0 … 7	… 15		23 … 31
Packet Type	Reserved	F	Total Length
Session ID			

Figure 9 – Common header

In detail, the common header contains the following information:

a) Packet Type (8 bits)

It indicates the type of this packet, and the encoding value is summarized in Table 1.

b) Reserved (7 bits)

This field is reserved for future use.

c) F (1 bit)

It is a flag bit used to indicate whether a request is accepted or not. This flag can be set in the following packets: SJC (Session Join Confirm), LJC (Local Join Confirm), ULC (User Leave Confirm), HIC (Handover Initiation Confirm), and HTA (Handover Transfer ACK). F = 1 indicates that the corresponding request is accepted. F is set to 0, otherwise.

d) Payload Length (16 bits)

It indicates the total length of this packet including the common header.

e) Session ID (32 bits)

This field is used to identify an MMCP session throughput the MMCP control operations. This value shall be predetermined before the MMCP session begins. A prospective MN will get this information, together with the IP address and the port number of the SM, via a different mechanism such as a web announcement.

8.2 Parameter format

The MMCP packets can include a variety of parameters following the common header. Each parameter is in the TLV (Type-Length-Value) format with 1-byte parameter type, 1-byte parameter length, and variable-length parameter values, as depicted in Figure 10.

0 … 7	15	23 … 31
Parameter Type	Reserved	Parameter Length
Parameter Values ···		

Figure 10 – Parameter TLV format

Table 2 summarizes the parameters used in MMCP with the corresponding type values and lengths.

Table 2 – MMCP parameters

Parameter name	Type value	Length
MN Identifier	0000 0001	Variable
PoA Identifier	0000 0010	Variable
Multicast Address	0000 0011	Variable
LMC Address	0000 0100	Variable
Data Channel Status	0000 0101	12 bytes
Membership	0000 0110	8 bytes

8.2.1 MN identifier

The parameter of MN ID is used to specify the concerned MN in the MMCP. The MN ID is usually given to a user by the service provider. The length of the MN ID depends on the type of services, as shown in Figure 11.

0 … 7	15	23 … 31
Parameter Type (0000 0001)	Reserved	Parameter Length
MN ID (Variable)		

Figure 11 – Parameter of MN identifier

a) Parameter Length (16 bits)

This field represents the length of this parameter in byte.

b) MN ID (variable)

It specifies the identifier of MN. Its length is a variable.

8.2.2 PoA identifier

The parameter of PoA ID is used to specify the concerned PoA, which may be a MAC address or an identifier.

0 7	15	23 31
Parameter Type (0000 0010)	Reserved	Parameter Length
PoA ID (Variable)		

Figure 12 – Parameter of PoA identifier

a) Parameter Length (16 bits)

   This field represents the length of this parameter in byte, including the parameter values as indicated in the figure.

b) PoA ID (variable)

   It specifies the identifier of PoA. Its length is a variable.

8.2.3 Multicast address

The parameter of multicast address is used to specify the IP multicast address and port number for the concerned multicast data channel.

0 7	15	23 31
Parameter Type (0000 0011)	Reserved	Parameter Length
Multicast Group Port Number		Multicast Group IP Address
Multicast Group IP Address: IPv4 (4 bytes), IPv6 (16 bytes)		

Figure 13 – Parameter of multicast address

a) Parameter Length (16 bits)

   This field represents the length of this parameter in byte, including the parameter values as indicated in the figure.

b) Multicast Group Port Number (16 bits)

   This specifies the port number of the concerned multicast data channel.

c) Multicast Group IP Address (32 bits or 128 bits)

   This specifies the IP multicast address. Its length depends on the IP version.

8.2.4 LMC address

The parameter of LMC address is used to specify the contact information of the concerned LMC: IP address and port number.

0 7	15	23 31
Parameter Type (0000 0100)	Reserved	Parameter Length
Port Number of LMC		IP Address of LMC
IP Address of LMC: IPv4 (4 bytes), IPv6 (16 bytes)		

Figure 14 – Parameter of LMC address

a) Parameter Length (16 bits)

   This field represents the length of this parameter in byte, including the parameter values as indicated in the figure.

b) Port Number of LMC (16 bits)

   This specifies the port number of the concerned LMC.

c) IP Address of LMC (32 bits or 128 bits)

   This specifies the IP address of LMC. The length depends on the IP version.

8.2.5 Data channel status

This 12-byte parameter is used to specify the statistics of the multicast data channel for an MN, such as total number of data packets and the elapsed time in the session. This parameter shall be included into an MMCP message, together with the corresponding MN ID parameter.

0 … 7	8 … 15	16 … 23	24 … 31
Parameter Type (0000 0101)	Reserved	Parameter Length	
Total Number of Packets Received (byte)			
Elapsed Time in Session (second)			

Figure 15 – Parameter of data channel status

a) Parameter Length (16 bits)

This field represents the length of this parameter in byte, which has a fixed value of 12.

b) Total Number of Packets Received (32 bits)

This specifies the total number of data packets (in byte) that the MN has so far received from the multicast data channel.

c) Elapsed Time in Session (32 bits)

This specifies the elapsed time (in seconds) during which the MN has participated in the session.

8.2.6 Membership

This 8-byte parameter is contained only in the ASR message that an LMC sends to the SM as an aggregation status report. This parameter is used to specify the total number of MNs attached to the concerned LMC. The corresponding ASR message will also include the status information (MN ID and Data Channel Status parameters) of all of the downstream MNs attached to the LMC.

0 … 7	8 … 15	16 … 23	24 … 31
Parameter Type (0000 0110)	Reserved	Parameter Length	
Total Number of MNs			

Figure 16 – Parameter of membership

a) Parameter Length (16 bits)

This field represents the length of this parameter in byte, which has a fixed value of 8.

b) Total Number of MNs (32 bits)

This specifies the total number of MNs attached to the LMC.

8.3 Packets for session join

This clause specifies the detailed structure for the MMCP packets used for Session Join and Local Join.

8.3.1 Session join request (SJR)

The SJR packet is constructed as follows.

0 … 31
Common Header (8 bytes)
MN Identifier (variable)
PoA Identifier (variable): optional

Figure 17 – Session join request

An SJR packet consists of the common header, the MN ID parameter, and PoA ID parameters (optional) for the concerned MN. When sending this message, the MN shall determine the MN ID and PoA ID values from its locally configured information. The PoA ID may be used by SM to determine the best LMC for the MN.

8.3.2 Session join confirm (SJC)

The SJC packet is constructed as follows.

0	7	15	23	31
Common Header (8 bytes)				
Multicast Address (variable)				
LMC Address (variable): optional				

Figure 18 – Session join confirm

In response to an SJR message, the SM sends the MN an SJC packet that consists of the common header, multicast address parameter, and LMC address (optional) parameters for the concerned MN. In the common header, the SJC packet shall indicate that the join request is accepted or not by using the 'F' flag bit.

The LMC address parameter is contained in the SJC packet only when an LMC needs to be assigned to the MN. The selection of the best LMC for the MN may be done based on the PoA ID contained in the SJR message of the MN. The detailed selection rule of the LMC is an implementation issue. On reception of the SJC message with the LMC address parameter, the MN shall perform the local join to the designated LMC.

8.3.3 Local join request (LJR)

The LJR packet is constructed as follows.

0	7	15	23	31
Common Header (8 bytes)				
MN Identifier (variable)				

Figure 19 – Local join request

After session join, the MN can perform the local join to the designated LMC by sending an LJR message. The LJR message contains the MN ID parameter following the common header.

8.3.4 Local join confirm (LJC)

The LJC packet consists of the common header only.

0	7	15	23	31
Common Header (8 bytes)				

Figure 20 – Local join confirm

The LMC sends an LJC packet to the MN in response to an LJR message. In the common header, the LJC packet shall indicate that the local join request is accepted or not by using the 'F' flag bit.

8.4 Packets for user leave

This clause specifies the detailed structure of the MMCP packets used for User Leave.

8.4.1 User leave request (ULR)

The ULR packet is constructed as follows.

0 7 15 23 31
Common Header (8 bytes)
MN Identifier (variable)

Figure 21 – User leave request

During the session, an MN may leave the session by sending a ULR message to its LMC or SM. The ULR packet is optional. That is, the SM or LMC will check the user leave through the status monitoring operation.

8.4.2 User leave confirm (ULC)

The ULC packet consists of the common header only.

0 7 15 23 31
Common Header (8 bytes)

Figure 22 – User leave confirm

The LMC or SM may respond to the MN with the ULC packet. In the common header, the ULC packet may indicate that the user leave request is accepted or not by using the 'F' flag bit. The ULC packet is optional. That is, the MN may terminate the session not waiting for the responding ULC message.

8.5 Packets for status monitoring

This clause specifies the detailed structure of the MMCP packets used for Status Monitoring.

8.5.1 User status report (USR)

The USR packet is constructed as follows.

0 7 15 23 31
Common Header (8 bytes)
MN Identifier (variable)
Data Channel Status (12 bytes)

Figure 23 – User status report

Each MN sends a periodic USR message to its LMC or SM. The USR message includes the MN ID parameter and Data Channel Status parameter. If the MN cannot get any statistics on the multicast data channel, the USR may not include the Data Channel Status parameter.

8.5.2 Aggregate status report (ASR)

Each LMC sends a periodic ASR packet to the SM. Each ASR packet contains all of the aggregated status information (MN Identifier parameter and Data Channel Status parameters) for the respective downstream MNs, together with the Membership parameter, as shown in Figure 24.

0	7	15	23	31
		Common Header (8 bytes)		
		Membership (8 bytes)		
		MN Identifier (variable) for MN #1		
		Data Channel Status (12 bytes) for MN #1		
		……		
		MN Identifier (variable) for MN #n		
		Data Channel Status (12 bytes) for MN #n		

Figure 24 – Aggregate status report

As shown in the figure, an ASR packet contains the aggregated parameters of the MN Identifier and Data Channel Status for all of the MNs attached to the LMC. In the ASR packet, the Membership parameter is mandatory, whereas the other parameters are optional. In case that a lot of MNs are attached to an LMC, an ASR cannot contain all of the status parameters for all the MNs. In this case, the LMC will send one or more ASR packets to the SM in a row.

8.5.3 User status probe (USP)

The USP packet consists of the common header only.

0	7	15	23	31
		Common Header (8 bytes)		

Figure 25 – User status probe

The SM or LMC may send an USP packet to the downstream LMC or MN that has not sent any ASR or USR packet for the preconfigured time interval. The corresponding LMC or MN shall respond to its parent node with an ASR or USR message.

8.6 Packets for handover support

This clause specifies the detailed structure of the MMCP packets used for handover support.

8.6.1 Handover initiation request (HIR)

The HIR packet is constructed as follows.

0	7	15	23	31
		Common Header (8 bytes)		
		MN Identifier (variable)		
		PoA Identifier (variable)		

Figure 26 – Handover initiation request

The HIR packet shall include the MN identifier and PoA identifier parameters. The PoA identifier represents the ID of the newly visited PoA by the MN. The PoA identifier format depends on the underlying access technology. Based on this ID of the new PoA, the old LMC shall be able to identify the corresponding new LMC. Then the old LMC will perform the subsequent operation for handover support with the new LMC.

8.6.2 Handover context transfer (HCT)

The HCT packet is constructed as follows.

0	7	15	23	31
Common Header (8 bytes)				
MN Identifier (variable)				
Multicast Address (variable)				

Figure 27 – Handover context transfer

On reception of the HIR packet, the old LMC sends an HCT message to the new LMC. The HCT packet shall include the MN identifier and Multicast Address parameters. On receipt of this HCT message, the new LMC will perform the IGMP/MLD join operation based on the values contained in the Multicast Address parameter.

8.6.3 Handover transfer acknowledgement (HTA)

The HTA packet contains the common header only.

0	7	15	23	31
Common Header (8 bytes)				

Figure 28 – Handover transfer acknowledgement

After the IGMP/MLD operation, the new LMC responds to the old LMC with an HTA packet. The HTA packet shall indicate that the handover context transfer is successfully performed by using the 'F' flag of the common header.

8.6.4 Handover initiation confirm (HIC)

The HIC packet is constructed as follows.

0	7	15	23	31
Common Header (8 bytes)				
LMC Address (variable)				

Figure 29 – Handover initiation confirm

In response to the HIR message, the old LMC shall send an HIC packet to the MN. The HIC packet shall contain the LMC address parameter for the new LMC to which the MN will be newly attached. The HIC packet shall indicate that the handover request is successfully performed by using the 'F' flag of the common header.

Annex A

Timers

(This annex does not form an integral part of this Recommendation | International Standard)

This annex summarizes the timers used in the MMCP.

a) Join Waiting Time (JWT)

   The JWT timer is used by the MN for session join. In session join, the MN sends an SJR message to the SM and waits for the responding SJC message from the SM during the JWT time. When the MN cannot receive the SJC message from the SM before the JWT timer expires, it realizes that the join request failed. The JWT timer can also be used by the MN for local join to the LMC. A specific value of JWT timer depends on the implementation.

b) Status Report Time (SRT)

   While a session is active, each MN shall send a USR message to its upstream LMC or SM for every status report time (SRT). The SRT parameter value may be locally configured. Each LMC will also send an ASR message to the SM every SRT time. A specific value of SRT timer depends on the implementation.

c) Status Probe Time (SPT)

   If an LMC has not received any USR message from an MN for the preconfigured Status Probe Time (SPT), it shall send a USP message to the concerned MN. The SPT value may be set to '3 x SRT'. The MN shall respond to its upstream LMC with the USR message, as soon as it receives a USP message. In a similar way, the SM may send a USP message to its downstream LMCs for status monitoring.

d) Handover Initiation Time (HIT)

   For reliable transmission of an HIR message for handover support, the handover initiation time (HIT) timer is used by the MN. After sending an HIR message to the old LMC, the MN waits for the responding HIC message for HIT time. MN will retransmit the HIR message to old LMC again, if there is no responding HIC message before the HIT timer expires. A specific value of HIT timer depends on the implementation.

e) Context Transfer Time (CTT)

   The Context Transfer Time (CTT) timer is used by the old LMC for reliable transmission of HCT messages. After sending an HCT message to the new LMC, the old LMC will wait for the responding HTA message from the new LMC for CTT time. A specific value of CTT timer depends on the implementation.

Annex B

State transition diagram

(This annex does not form an integral part of this Recommendation | International Standard)

This annex describes the state transition diagram of MMCP for information.

Figure B.1 gives the state transition diagram for the SM.

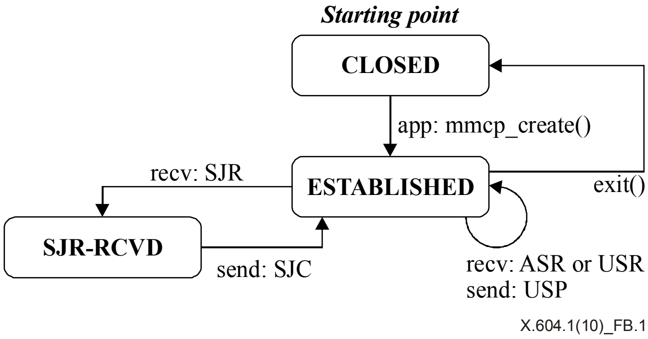

Figure B.1 – State transition at SM

In the SM side, an MMCP control session is established when an application calls an appropriate initiation function (e.g, mmcp_create()). In the ESTABLISHED state, when the SM receives an SJR message from a promising MN, it goes into SJR-RCVD state. After responding to the MN with an SJC message, the SM will be in the ESTABLISHED state again. During the ESTABLISHED state, the SM may receive one or more ASR or USR messages from the LMC or the MN. After the application is terminated, the SM will go into the CLOSED state.

Figure B.2 gives the state transition diagram for the LMC. The LMC is activated by an application's call such as mmcp_lmc_join(). In the initiation process, an LMC shall join the SM by sending an SJR message. If the LMC receives the responding SJC message with an indication of success from the SM, it will be in the ESTABLISHED state.

In the ESTABLISHED state, the LMC will respond to any LJR message with the LJC message. In status monitoring, the LMC may receive periodic USR messages from its downstream MNs, and/or it may send periodic ASR messages to the SM. For a non-responding MN, the LMC may send a USR message. The LMC will also respond to a USP message of the SM with the ASR message.

For handover support, when the LMC receives an HIR message from the MN, it goes into the HIR-RCVD state and sends an HCT message to the associated other LMC. In the HCT-SENT state, if the LMC receives an HTA message from the other LMC, then it sends the responding HIC message to the associated MN. When an LMC receives an HCT message from the other LMC, it responds with the HTA message after performing the IGMP/MLD join.

Figure B.3 shows the state transition diagram of the MN. The MN starts an MMCP session by an application call such as mmcp_join(). After session join and local join, the MN will go into the ESTABLISHED state. In the ESTABLISHED state, the MN will send periodic USR messages to its upstream LMC or SM. The MN will respond to the USP message with the USR message. For handover support, the MN sends an HIR message to the old LMC, and goes into the HIR-SENT state. On receipt of the responding HIC message, the MN will go back to the ESTABLISHED state.

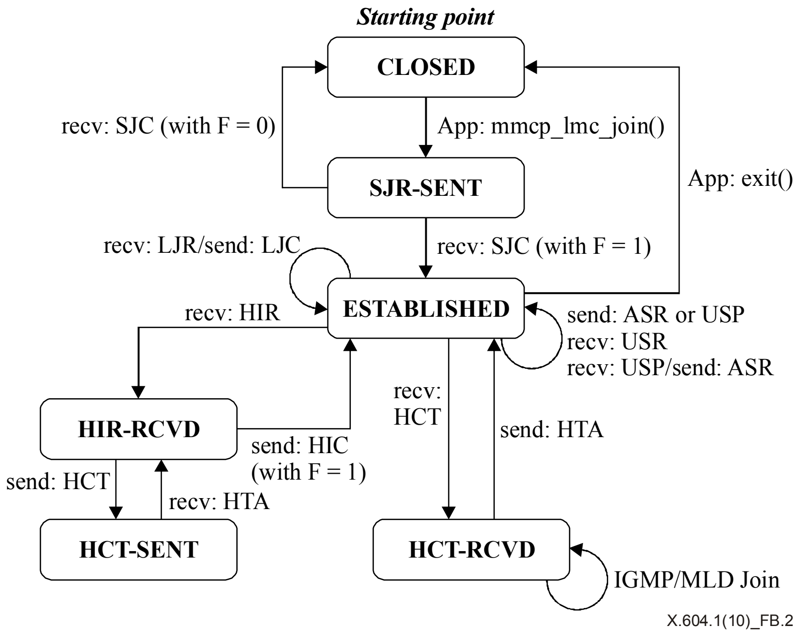

Figure B.2 – State transition at LMC

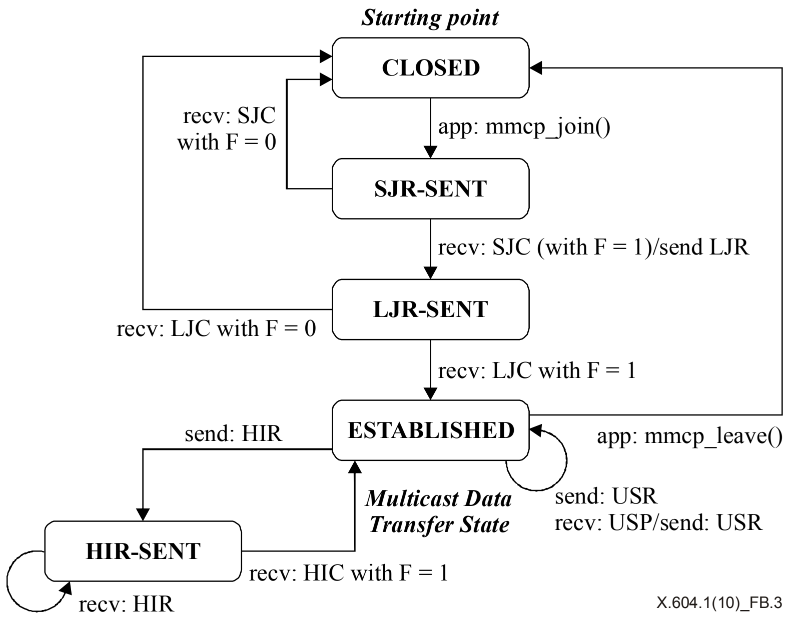

Figure B.3 – State transition at MN

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Printed in Switzerland
Geneva, 2011