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Multicast Channel Allocation Protocol (MCAP) for IEEE 1394

STATUS OF THIS DOCUMENT

ABSTRACT

This document specifies how IP-capable Serial Bus devices may allocate IEEE 1394 channel number(s) for use in the multicast transmission of IP datagrams. It defines the necessary methods, data structures and codes for that purpose.

See also the most recent revision of draft-ietf-ip1394-ipv4 for a specification of the transport of IPv4 datagrams over IEEE 1394.

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TABLE OF CONTENTS

1. INTRODUCTION

This document specifies how IP-capable Serial Bus devices may allocate IEEE 1394 channel number(s) for use in the multicast transmission of IP datagrams. It defines the necessary methods, data structures and codes for that purpose.

The group of IEEE standards and supplements, draft or approved, related to IEEE Std 1394-1995 is hereafter referred to either as 1394 or as Serial Bus.

The draft specification for the transport of IPv4 datagrams over 1394, draft-ietf-ip1394-ipv4, requires broadcast and multicast IP datagrams to be transported within 1394 asynchronous streams. Before an asynchronous stream may be used it is necessary to allocate a 1394 resource, a channel number. The IPv4 draft specification describes how a channel number is allocated for all broadcast IP datagrams; this same channel number is also used, by default, for multicast traffic.

In cases where it is desirable to use a different channel number for particular multicast groups, methods are needed to allocate a channel number, advertise its existence and ultimately deallocate the channel number when it is no longer needed. This document describes such methods and names them "multicast channel allocation protocol" (MCAP).

Although the definition of MCAP is motivated by the particular requirements of 1394, the methods are extensible to other link media.

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2. DEFINITIONS AND NOTATION

2.1 Conformance

When used in this document, the keywords "may", "optional", "recommended", "required", "shall" and "should" differentiate levels of requirements and optionality and are to be interpreted as described in RFC 2119.

Several additional keywords are employed, as follows:

expected: A keyword used to describe the behavior of the hardware or software in the design models assumed by this standard. Other hardware and software design models may also be implemented.

ignored: A keyword that describes bits, octets, quadlets or fields whose values are not checked by the recipient.

reserved: A keyword used to describe objects---bits, octets, quadlets and fields---or the code values assigned to these objects in cases where either the object or the code value is set aside for future standardization. Usage and interpretation may be specified by future extensions to this or other standards. A reserved object shall be zeroed or, upon development of a future standard, set to a value specified by such a standard. The recipient of a reserved object shall not check its value. The recipient of an object defined by this standard as other than reserved shall check its value and reject reserved code values.

2.2 Glossary

The following terms are used in this standard:

bus ID: A 10-bit number that uniquely identifies a particular bus within a group of multiple interconnected buses. The bus ID is the most significant portion of a node's 16-bit node ID. The value 0x3FF designates the local bus; a node shall respond to requests addressed to its 6-bit physical ID if the bus ID in the request is either 0x3FF or the bus ID explicitly assigned to the node.

IP datagram: An Internet message that conforms to the format specified by RFC 791.

node ID: A 16-bit number that uniquely identifies a Serial Bus node within a group of multiple interconnected buses. The most significant 10 bits are the bus ID and the least significant 6 bits are the physical ID.

octet: Eight bits of data.

packet: Any of the 1394 primary packets; these may be read, write or lock requests (and their responses) or stream data. The term "packet" is used consistently to differentiate 1394 packets from ARP requests/responses or IP datagrams.

physical ID: On a particular bus, this 6-bit number is dynamically assigned during the self-identification process and uniquely identifies a node on that bus.

quadlet: Four octets, or 32 bits, of data.

stream packet: A 1394 primary packet with a transaction code of 0x0A that contains a block data payload. Stream packets may be either asynchronous or isochronous according to the type of 1394 arbitration employed.

2.3 Abbreviations

The following are abbreviations that are used in this standard:

CAM Channel allocation manager
MCAP Multicast channel allocation protocol
IP Internet protocol (within the context of this document, IPv4)

3. CHANNEL ALLOCATION MANAGER

MCAP requires the presence of a channel allocation manager (CAM) to process requests, allocate or deallocate Serial Bus channel numbers and advertise the mapping from group addresses to their corresponding channels.

The identity of the CAM and the method of its selection have not yet been discussed by the working group.

Consensus has been reached that the CAM listens for messages (whose format is described below) on the default multicast channel specified by the NETWORK_CHANNELS register and transmits advertisements and other responses on the same channel. The details of CAM operations are described in section 5.

4. MCAP MESSAGE FORMAT

MCAP messages, whether sent by a multicast source or recipient or the CAM, share a common format illustrated below. The first eight octets of the message are fixed; the remainder consists of variable-length tuples, each of which encodes information about a particular multicast group.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             length            |           checksum            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        bus_ID         |         reserved        |    opcode     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                          message data                         +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5 - MCAP message format

Field usage in an MCAP message is as follows:

length: This field shall contain the size, in octets, of the entire MCAP message.

checksum: This field shall contain a checksum calculated on the entire MCAP message. The checksum shall be one’s complement of the sum of all the 16-bit words in the message; arithmetic overflow is discarded. For the purpose of calculating the checksum, the *checksum* field is treated as if zero.

bus_ID: This field shall specify the 10-bit bus ID for which information in the MCAP message is valid. The value of *bus_ID* shall be equal to the most significant 10 bits of the sender’s NODE_IDS register.

opcode: This field shall have one of the values specified by table 1 below.

Table 1 - MCAP *opcode* values

opcode	Name	Comment
0	Advertise	Sent by the CAM to broadcast the current mapping from each group address to its corresponding channel number.
1	Request	Sent by a multicast source to request the allocation of a channel number or to refresh the remaining lifetime of a channel number allocation.
2	Release	Optionally sent by a multicast source to release a channel number at a future time.
3	Error	Sent by the CAM when it is unable to satisfy a channel number allocation request.
4	Solicit	Sent to request the CAM advertise the current channel mapping(s) as soon as possible.

message data: The remainder of the MCAP message is variable in length and shall consist of zero or more group address descriptors with the format illustrated below.

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    length     |     type      |           reserved            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  expiration   |    channel    |     speed     |    status     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           bandwidth                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                         group_address                         +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5 - MCAP group address descriptor format

length: This field shall contain the size, in octets, of the MCAP group address descriptor.

type: This field shall have a value of one, which indicates a group address descriptor.

expiration: The usage of this field varies according to *opcode*. For solicit and error messages the *expiration* field shall be ignored. Otherwise this field shall contain a time-stamp, in seconds, that specifies a future time for the release of the channel number specified by *channel*. Time is expressed in terms of the CYCLE_TIME.*seconds* and a match occurs when *expiration* equals the most significant seven bits of the CYCLE_TIME register.

channel: This field shall specify either a valid channel number, in the range zero to 63 inclusive, or else indicate an invalid channel number with a value of 0xFF. All other values are reserved. The usage of this field varies according to *opcode*, as shown in the table below.

Operation	Usage of *channel*
Advertise	Channel number allocated for the multicast *group_address*
Request	Suggested channel number (hint)
Release	Ignored
Error	Ignored
Solicit	Ignored

speed: This field shall be ignored except for advertise and request messages, in which case it shall specify the speed at which stream packets for the indicated *channel* are transmitted. The encoding used for *speed* is specified by the table below; all values not specified are reserved.

Value	Speed
0	S100
1	S200
2	S400
3	S800
4	S1600
5	S3200

status: This field shall be ignored except for error messages, in which case it shall characterize the reason(s) the CAM did not allocate a requested channel number. The encoding for this field is yet to be determined.

bandwidth: This field shall be ignored; it is allocated in the group address descriptor to accommodate future extensions to MCAP that specify quality of service and utilize the isochronous capabilities of Serial Bus.

group_address: This variable length field shall specify the IP address of a particular multicast group. The length of *group_address*, in octets, is derived from the length of the group address descriptor by subtracting 12 from the *length* field.

5. MCAP OPERATIONS

MCAP is a cooperative protocol implemented by multicast senders and recipients and the CAM. The participants exchange messages over the default multicast channel used by all IP-capable nodes on a particular Serial Bus.

The *bus_ID* field in all MCAP messages shall be equal to the most significant 10 bits of the sender’s NODE_IDS register.

5.1 Advertisement of channel mappings

The CAM shall periodically broadcast an advertisement of all multicast group addresses allocated a channel number that differs from the default multicast channel number. An advertisement shall consist of a single MCAP message with an *opcode* of zero which contains zero or more group address descriptors (one for each group address assigned a channel number other than that specified by the NETWORK_CHANNELS register).

Within each group address descriptor, the *group_address* and *channel* fields associate a multicast group address with a Serial Bus channel number. More than one multicast group address may be mapped to a single Serial Bus channel number by means of separate group address descriptors. The *speed* field specifies the maximum 1394 speed at which any of the senders within the multicast group transmits data. The *expiration* field specifies a future time when the CAM will deallocate the channel number.

No more than ten seconds shall elapse from the transmission of the most recent advertisement before the CAM initiates transmission of the subsequent advertisement.

5.2 Request for channel allocation

Before any multicast transmission on other than the default channel number specified by the NETWORK_CHANNELS register, a sender within a multicast group shall insure that the CAM has allocated a channel number.

A multicast sender should first listen for an MCAP advertisement. If the multicast group address is already mapped to a channel number, the sender need not make a channel allocation request and may use the advertised channel number for multicast transmission.

Otherwise the intended multicast sender shall transmit an MCAP message with an *opcode* of one which contains one or more group address descriptors. Within each group address descriptor the *group_address* field shall specify the multicast group address for which a channel number is requested. If the requester has reasons to prefer a particular channel number, this may be specified as a hint in the *channel* field but the CAM is not obligated to allocate that channel. The intended multicast sender shall also specify, for each multicast group address, the maximum *speed* at which it intends to transmit data and the *expiration* time for the channel allocation.

When the CAM receives an MCAP request for channel allocation(s), it shall attempt to allocate a channel number in accordance with its own policies and the availability of Serial Bus channel number(s).

If a channel is already allocated for the specified *group_address*, the CAM shall take no additional action other than to confirm the channel number mapping in the next MCAP advertisement. If the *channel* number hint in the allocation request differs from the channel number actually allocated, the CAM should transmit an advertisement as soon as possible. Otherwise the advertisement should be transmitted at the next scheduled time.

If no channel is allocated for the specified *group_address*, the CAM shall select a channel number and attempt to allocate it from the isochronous resource manager’s CHANNELS_AVAILABLE register. The selection criteria shall be based upon the *channel* hint supplied in the request and the CAM’s own policies; a value of 0xFF for *channel* indicates that the requester has provided no hint. If the chosen channel number is unavailable, the CAM may attempt to allocate a different channel number from CHANNELS_AVAILABLE. The retry algorithms are subject to policies implemented by the CAM (*e.g.*, some implementations might not allocate the last available channel but elect to aggregate multicast group addresses to already allocated channel(s)).

When the CAM successfully allocates a channel number or assigns the multicast group address to an already allocated channel number, the new mapping from multicast group address to channel number shall be advertised as soon as possible. The MCAP advertisement constitutes a response to the channel allocation request and permits the multicast sender to commence transmissions.

Otherwise, the CAM shall transmit an error response as described below.

5.3 Error response to channel allocation

The CAM shall transmit an MCAP error response message whenever one or more multicast group addresses specified in an MCAP channel allocation request message have not been mapped to other than the default multicast channel number.

Multicast channel allocation may fail because no channel numbers are available or because CAM policy prevents the allocation. For whatever reason, the MCAP error response message shall contain a group address descriptor for each failure. The *group_address* field shall identify the multicast group and the *status* field shall contain a code that indicates the nature of the error. All other fields within the group address descriptor shall be ignored.

5.4 Release of unneeded channel(s)

When a multicast sender intends to cease transmissions for a multicast group that is not mapped to the default multicast channel, it may notify the CAM by means of an MCAP release message. The usage of the release message is optional, since the CAM will automatically deallocate the channel number when its *expiration* time is reached.

An MCAP release message has an *opcode* value of three and contains one or more group address descriptors. Each descriptor identifies the *group_address* whose channel number is to be released. The *expiration* field shall specify a time at least 30 seconds in the future for the release of the channel number. All other fields within the group address descriptor shall be ignored.

In response to an MCAP release message that identifies a *group_address* in the current channel map, the CAM shall update the expiration time for the channel with the value of *expiration* and shall transmit an MCAP advertisement message as soon as possible. The advertisement that reflects the updated expiration time is the response expected by the sender of the MCAP release message.

Whether multicast senders utilize the optional MCAP release message or not, channel allocations eventually expire for unused channel numbers. When the *expiration* time associated with a particular multicast group and associated channel is reached (as measured by the CAM's CYCLE_TIME register), the CAM shall remove the multicast group and channel number from the current channel map. Once the CAM has transmitted an MCAP advertisement message in which no group descriptors reference a previously allocated channel number, the CAM shall deallocate the channel number in the isochronous resource manager's CHANNELS_AVAILABLE register.

5.5 Solicitation of the channel map

Multicast recipients or senders may request the CAM to advertise the channel map by transmitting an MCAP solicitation request. No group address descriptors are included with this message; the *opcode* value of five requests the CAM identified by *bus_ID* to advertise the channel map.

Originators of MCAP solicitation requests shall limit the rate at which they are transmitted. Subsequent to sending a solicitation request, neither the originator nor any other node that observes the request shall send another MCAP solicitation request until either a) 10 seconds have expired or b) an MCAP advertisement has been observed.

The CAM should transmit an MCAP advertisement message as soon as possible in response to the solicitation request.

5.6 Periodic refresh of channel allocation(s)

As described in 5.4 above, the CAM shall remove expired multicast group address and channel number pairs from the current channel map and ultimately return channel number(s) to the CHANNELS_AVAILABLE pool when no longer used by any multicast group.

In order to prevent this occurrence for active multicast groups, at least one sender within a multicast group shall periodically extend the *expiration* time for the channel map by means of an MCAP channel allocation request message (see 5.1). Although the CAM does not allocate a new channel, the request causes the expiration time to be updated to a new future value. The frequency of MCAP channel allocation request messages and the *expiration* time specified in each should be coordinated such that at least three request messages are transmitted before the *expiration* time specified by the earliest of the three is reached.

In multicast groups where there is more than one sender it is desirable to limit the number of MCAP channel allocation request messages. The ideal situation is for one sender to generate the requests. If this sender intends to leave the multicast group, one of two events occur: either the sender transmits the optional MCAP release message or it ceases transmission of allocation request messages. In the first case, one of the other senders within the multicast group is expected to observe the release message and initiate its own transmission of MCAP channel allocation request messages. Otherwise, if the time remaining before channel expiration falls below two seconds, that sender should initiate its own transmission of MCAP channel allocation request messages. In the latter case, the allocation request shall be transmitted at least one second before the expiration time.

6. SECURITY CONSIDERATIONS

This document specifies the use of an unsecured link layer, Serial Bus, for the transport of IPv4 datagrams. Serial Bus is vulnerable to denial of service attacks; it is also possible for devices to eavesdrop on data or present forged identities. Implementers who utilize Serial Bus for IPv4 should consider appropriate counter-measures within application or other layers.

7. ACKNOWLEDGEMENTS

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