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Address Resolution for IP datagrams over MPEG-2 networks

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Abstract

This document describes the process of binding/associating IPv4/IPv6 addresses with MPEG-2 Transport Streams (TS). This procedure is known as Address Resolution (AR), or Neighbour Discovery (ND). Such address resolution complements the higher layer resource discovery tools that are used to advertise IP sessions. In MPEG-2 networks, an IP address must be associated with a Packet ID (PID) and a specific Transmission Multiplex The document reviews current methods. It also describes the interaction with well-known protocols for address management including DHCP, ARP, and NDP, and provides guidance on usage.

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1. Introduction

The MPEG-2 Transport Stream (TS) provides a time-division multiplexed (TDM) stream that may contain audio, video and data information, including encapsulated IP datagrams. It is defined in specification ISO/IEC 138181 [ISO-MPEG2]. Each Layer-2 frame, known as a TS Packet, contains a 4 byte header and 188 bytes of payload. Each TS Packet is associated with a single TS Logical Channel, identified by a 13 bit Packet ID (PID) value that is carried in the MPEG-2 TS Packet header.

The MPEG-2 standard also defines a control plane that may be used to transmit control information to Receivers using System Information (SI) Tables [ETSI-SI, ETSI-SI1], or Program Specific Information (PSI) Tables.

To utilise the MPEG-2 TS as an IP link, a sender must associate an IP address with a particular Transmission Multiplex, and within the multiplex identify the specific PID to be used. This document calls this mapping Address Resolution (AR) [ipdvb-arch]. In some AR schemes, the MPEG-2 TS address space is sub-divided into logical contexts known as Platforms. Each platform associates an IP service provider with a separate context that share a common MPEG-2 TS (use the same PID value).

MPEG-2 Receivers may use a Network Point of Attachment (NPA) [ipdvb-arch] to uniquely identify the L2 node within the MPEG-2 transmission network. An example of an NPA is the IEEE Medium Access Control (MAC) address. Where such addresses are used, these must also be signalled by the AR procedure. Finally, address resolution may need to signal the format of the data being transmitted, for example, the encapsulation, any L2 encryption method and any compression scheme [ID-IPDVB-ARCH].

The remainder of the document describes current mechanisms and their use to associate an IP address with the corresponding TS Multiplex, PID value, the MAC address and/or Platform ID. A range of approaches is described, including Layer-2 methods (utilising MPEG-2 SI tables), and protocols at the IP level (including the IPv4 Address Resolution Protocol, ARP [RFC826] and the IPv6 Neighbor Discovery Protocol, NDP [RFC2461]). Interactions and dependencies between these methods and the encapsulation methods are described.

2. Conventions used in this document

AIT: Application Information Table specified by the Multimedia Home Platform (MHP) specifications [ETSI-MHP]. This table may carry IPv4/IPv6 to MPEG-2 TS address resolution information.

ATSC: Advanced Television Systems Committee [ATSC]. A framework and a set of associated standards for the transmission of video, audio, and data using the ISO MPEG-2 standard.

b: bit. For example, one byte consists of 8b.

B: Byte. Groups of bytes are represented in Internet byte order.

DSM-CC: Digital Storage Media Command and Control [ISO-DSMCC]. A format for transmission of data and control information in an MPEG-2 Private Section, defined by the ISO MPEG-2 standard.

DVB: Digital Video Broadcast [ETSI-DVB]. A framework and set of associated standards published by the European Telecommunications Standards Institute (ETSI) for the transmission of video, audio, and data, using the ISO MPEG-2 Standard.

DVB-RCS: Digital Video Broadcast Return Channel via Satellite. A bi-directional IPv4/IPv6 service employing low-cost Receivers.

Encapsulator: A network device that receives PDUs and formats these into Payload Units (known here as SNDUs) for output as a stream of TS Packets.

INT: Internet/MAC Notification Table. A uni-directional addressing resolution mechanism using SI and/or PSI Tables.

MAC: Medium Access Control [IEEE-802.3]. A link layer protocol defined by the IEEE 802.3 standard (or by Ethernet v2 [DIX]).

MAC Header: The link layer header of the IEEE 802.3 standard [IEEE-802.3] or Ethernet v2 [DIX]. It consists of a 6B destination address, 6B source address, and 2B type field (see also NPA, LLC).
MAC: Medium Access and Control of the Ethernet IEEE 802 standard of protocols (see also NPA).

MHP: Multimedia Home Platform. An integrated MPEG-2 multimedia receiver, that may (in some cases) support IPv4/IPv6 services.

MMT: Multicast Mapping Table (proprietary extension to DVB-RCS defining an AR table that maps IPv4 multicast addresses to PID values).

MPE: Multiprotocol Encapsulation [ETSI-DAT; ATSC-DAT; ATSC-DATG]. A scheme that encapsulates PDUs, forming a DSM-CC Table Section. Each Section is sent in a series of TS Packets using a single TS Logical

Channel.

MPEG-2: A set of standards specified by the Motion Picture Experts Group (MPEG), and standardized by the International Standards Organisation (ISO/IEC 113818-1) [ISO-MPEG2], and ITU-T (in H.220).

NPA: Network Point of Attachment. In this document, refers to a 6 byte destination address (resembling an IEEE MAC address) within the MPEG-2 transmission network that is used to identify individual Receivers or groups of Receivers.

PID: Packet Identifier [ISO-MPEG2]. A 13 bit field carried in the header of TS Packets. This is used to identify the TS Logical Channel to which a TS Packet belongs [ISO-MPEG2]. The TS Packets forming the parts of a Table Section, PES, or other Payload Unit must all carry the same PID value. The all 1s PID value indicates a Null TS Packet introduced to maintain a constant bit rate of a TS Multiplex. There is no required relationship between the PID values used for TS Logical Channels transmitted using different TS Multiplexes. The all 1s PID value indicates a Null TS Packet introduced to maintain a constant bit rate of a TS Multiplex. There is no required relationship between the PID values used for TS Logical Channels transmitted using different TS Multiplexes.

Private Section: A syntactic structure constructed in accordance with Table 2-30 of [ISO-MPEG2]. The structure may be used to identify private information (i.e. not defined by [ISO-MPEG2]) relating to one or more elementary streams, or a specific MPEG-2 program, or the entire Transport Stream. Other Standards bodies, e.g. ETSI, ATSC, have defined sets of table structures using the private_section structure. A Private Section is transmitted as a sequence of TS Packets using a TS Logical Channel. A TS Logical Channel may carry sections from more than one set of tables.

PSI: Program Specific Information [ISO-MPEG2]. PSI is used to convey information about services carried in a TS Multiplex. It is carried in one of four specifically identified table section constructs [ISO-MPEG2], see also SI Table.

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Receiver: Equipment that processes the signal from a TS Multiplex and performs filtering and forwarding of encapsulated PDUs to the network-layer service (or bridging module when operating at the link layer).

SI Table: Service Information Table [ISO-MPEG2]. In this document, this term describes a table that is been defined by another standards body to convey information about the services carried in a

TS Multiplex. A Table may consist of one or more Table Sections, however, all sections of a particular SI Table must be carried over a single TS Logical Channel [ISO-MPEG2].

SNDU: Subnetwork Data Unit. An encapsulated PDU sent as an MPEG-2 Payload Unit.

Table Section: A Payload Unit carrying all or a part of an SI or PSI Table [ISO-MPEG2].

TS: Transport Stream [ISO-MPEG2], a method of transmission at the MPEG-2 level using TS Packets; it represents layer 2 of the ISO/OSI reference model. See also TS Logical Channel and TS Multiplex. to two terrestrial TV transmission cells.

TS Logical Channel: Transport Stream Logical Channel. In this document, this term identifies a channel at the MPEG-2 level [ISO-MPEG2]. This exists at level 2 of the ISO/OSI reference model. All packets sent over a TS Logical Channel carry the same PID value (this value is unique within a specific TS Multiplex). The term "Stream" is defined in MPEG-2 [ISO-MPEG2]. This describes the content carried by a specific TS Logical Channel (see, ULE Stream). Some PID values are reserved (by MPEG-2) for specific signalling. Other standards (e.g., ATSC, DVB) also reserve specific PID values.

TS Multiplex: In this document, this term defines a set of MPEG-2 TS Logical Channels sent over a single lower layer connection. This may be a common physical link (i.e. a transmission at a specified symbol rate, FEC setting, and transmission frequency) or an encapsulation provided by another protocol layer (e.g. Ethernet, or RTP over IP). The same TS Logical Channel may be repeated over more than one TS Multiplex (possibly associated with a different PID value) [ID-ipdvb-arch], for example to redistribute the same multicast content to two terrestrial TV transmission cells.

TS Packet: A fixed-length 188B unit of data sent over a TS Multiplex [ISO-MPEG2]. Each TS Packet carries a 4B header, plus optional overhead including an Adaptation Field, encryption details and time stamp information to synchronise a set of related TS Logical Channels.

UDL: Unidirectional link: A one-way transmission IP over DVB link, e.g., a broadcast satellite link.

ULE Stream: An MPEG-2 TS Logical Channel that carries only ULE encapsulated PDUs. ULE Streams may be identified by definition of a stream_type in SI/PSI [ISO_MPEG2].

3. Address Resolution Requirements

The MPEG IP address resolution process is independent of the choice of encapsulation and needs to support a set of IP over MPEG-2 encapsulation formats, including MPE [ETSI-DAT,ETSI-DAT1, ATSC-DAT]) and the IETF-defined Ultra Lightweight Encapsulation (ULE) [ID-ARCH,ID-ULE].

The general IP over MPEG-2 AR requirements are summarized below:

- A scalable and efficient transmission.
- A method to represent the AR information.
- Support for scoping of the addresses.
- Incremental update of clients with AR information.
- Procedures for purging stale client AR information.
- A method to identify the Server sourcing AR information.
- A method to install AR information at the AR server (unsolicited registration).
- Security associations to authenticate the AR information.

An MPEG-2 Transmission Network may support multiple IP networks. If this is the case, it is important to recognise the context (scope) within which an address is resolved, to prevent packets from one addressed scope leaking into other scopes. Examples of overlapping IP address assignments include:

(i) Private unicast addresses (e.g. in IPv4, 10/8 prefix; 172.16/12 prefix; 192.168/16 prefix) should be confined to one addressed area. IPv6 also defines link-local addresses that must not be forwarded beyond the link on which they were first sent.

(ii) Some multicast addresses, (e.g., the scoped multicast addresses sometimes used in private networks). These are only valid within an addressed area (examples for IPv4 include; 239/8; 224.0.0/24; 224.0.1/24). Similar cases exist for some IPv6 multicast addresses.

(iii) Scoped multicast addresses. Forwarding of these addresses is controlled by the scope associated with the address.

Overlapping address assignments may also occur at L2, where the same NPA/MAC address is used to identify multiple receivers [ID-IPDVB-ARCH]:

(i) An NPA unicast address must be unique within the addressed area. The IEEE assigned MAC addresses used in Ethernet LANs are Globally unique. If the NPA addresses are not globally unique, an NPA address must only be re-used by receivers in different addressed (scoped) areas.

(ii) The NPA broadcast address (all 1 MAC address). Traffic with this address should be confined to one addressed area.

(iii) IP and other protocols may view sets of MAC multicast addresses as link-local, and may produce unexpected results if frames with these address are distributed across several private networks.

Reception of unicast packets destined for another addressed area will lead to an increase in the rate of received packets by systems connected via the network. Reception of the additional network traffic may contribute to processing load, but should not lead to unexpected protocol behaviour. It does however introduce a potential Denial of Service (DoS) opportunity. When the Receiver operates as an IP router, the receipt of such a packet can lead to unexpected protocol behaviour.

3.1 Unicast Support

Unicast address resolution may be required at two levels. At the upper level, the AR procedure needs to associate an IP address with a specific NPA/MAC address. At the lower level, the IP (or MAC) address needs to be associated with a specific TS Logical Channel (PID value) and the corresponding TS Multiplex.

The same unicast IP address may be associated with more than one TS Logical Channel within the same scope [DVB-DAT]. These may have different content, but there is also the possibility of a Receiver receiving duplicated copies of packets.

3.2 Multicast Support

Multicast is an important application for MPEG-2 Transmission Networks, since it exploits the advantages of native support for link broadcast.

Multicast address resolution occurs at one level in associating a specific L2 address with am IP Group Destination Address (section 5). In IPv4 and IPv6 over Ethernet, this association is normally a direct mapping, and this is the default method also specified in both ULE [ID-IPDVB-ULE] and in MPE [ETSI-DAT].

Address resolution must also occur at the MPEG-2 level (section 4). The goal of this multicast address resolution is the association of an IPv4 or IPv6 multicast address with a specific TS Logical Channel (PID value) and the corresponding TS Multiplex. This association needs to permit a large number of active multicast groups, and should minimise the processing load at the Receiver when filtering and forwarding IP multicast packets. For example, schemes that may be easily implemented in hardware would be beneficial, since these may relieve the drivers and operating systems from discarding unwanted multicast traffic.

There are specific issues concerning IPv4 and IPv6 multicast over MPEG-2 Transmission Networks:

(i) Mapping IP multicast groups to the underlying MPEG-2 TS Logical Channel (PID) and the MPEG-2 TS Multiplex.

(ii) Provide signalling information to allow a receiver to locate an IP multicast flow within an MPEG-2 TS Multiplex.

(iii) Determining group membership (e.g. utilising IGMP/MLD).

Methods are required to identify the scope of an address when an MPEG-2 transmission network supports several logical IP network and carries groups within different multicast scopes.

Appropriate procedures need to specify the correct action when the same multicast group is available on separate TS Logical Channels. This could arise when different end hosts act as senders to contribute IP packets with the same IP Group Destination Address in the ASM address range.

Another different case arises when a Receiver could receive more than one copy of the same packet (e.g. when packets are replicated across different TS Logical Channels, or even different TS Multiplexes, a method also known as Simulcasting [DVB-DAT]). In this case, at the IP level, the host/router may be unaware of this duplication and it needs to be detected by other means.

4. MPEG-2 Address Resolution

In this section, current MPEG-2 address resolution mechanisms are reviewed.

4.1 Static configuration.

The static mapping option, where IP addresses or flows are statically mapped to specific PIDs is the equivalent to signalling "out-of-band". The application programmer, installing engineer, or user receives the mapping via some outside means, not in the MPEG-2 TS. This is useful for testing, experimental networks, small subnetworks and closed domains.

A single "well-known" PID is a specialisation of this. This scheme is used by current DOCSIS cable modems [DOCSIS], where all IP traffic is placed into the specified TS stream. Section or MAC filtering may be used to differentiate subnetworks.

4.1.1 MPEG-2 Cable Networks

Cable networks use a different transmission schemes for downstream, (headend to cable modem/STB) and upstream (cablemodem/STB to headend) transmission.

The information is sent (on the downstream) to the STBs as IP/Ethernet packets encapsulated in MPEG-2 TS Packets sent on a single well-known TS Logical Channel (PID); there is no use of inband tables. On the upstream, the common approach is to use Ethernet framing, rather than IP/Ethernet over MPEG-2, although other proprietary schemes also continue to be used.

Until the deployment of DOCSIS and EuroDOCSIS, most address resolution schemes in cable networks for IP traffic was proprietary, and did not usually employ a table-based address resolution method. Proprietary methods continue to be used in some cases where STBs require interaction. In this case, equipment at the headend may act as gateways between the cablemodem/STB and the Internet. These gateways receive L2 information and allocate an IP address.

DOCSIS utilises DHCP for IP client configuration. The Cable Modem Terminal System (CMTS) provides a DHCP server that allocates IP addresses to DOCSIS cable modems and STBs. The MPEG-2 Transmission Network provides a L2 bridged network to the cable modem. This usually acts as a DHCP relay for IP devices [RFC2131, RFC3256]. Issues in deployment of IPv6 are described in [ID-V6OPS-DEPLOY].

4.2 MPEG-2 Table-Based Address Resolution

The information about the set of MPEG-2 TS streams carried over a TS Multiplex can be distributed via tables that are assigned a specific and well-known set of PID values. This design requires access to and processing of the SI Table information [ETSI-SI, ETSI-SI1]. This scheme reflects the complexity of delivering and co-ordinating the various TS associated with multimedia TV. A TS Multiplex may provide AR information for IP services by integrating additional information into the existing MPEG-2 tables or by transmitting additional SI Tables specific to the IP service.

Examples of MPEG-2 Table usage to allow an MPEG-2 Receiver to identify the appropriate PID and multiplex associated with a specific IP address include:

(i) IP/MAC Notification Table (INT) in the DVB Data standard [ETSI-DAT]. This provides uni-directional address resolution of IPv4/IPv6 multicast addresses to MPEG-2 TS.

(ii) Application Information Table (AIT) in the Multimedia Home Platform (MHP) specifications [ETSI-MHP].

(iii)Multicast Mapping Table (MMT) an MPEG-2 Table employed by some DVB-RCS systems to provide uni-directional address resolution of IPv4 multicast addresses to MPEG-2 TS.

The MMT and AIT are used for specific applications. The INT [DVB-DAT] is a more general DVB standard, that supports MAC, IPv4, and IPv6 AR when used in combination with the other MPEG-2 tables.

4.2.1 IP/MAC Notification Table (INT) and its usage

The INT provides a mechanism for carrying information about the location of IP/L2 flows within a DVB network. The INT defines the concept of a Platform_ID, which may identify the addressing scope for a set of IP/L2 streams and/or Receivers. A Platform may span several transport streams within one or multiple DVB multiplexes and represents a single IP network with a harmonized address space (i.e. addressing scope). This allows for the coexistence of several non-harmonized IP/MAC address spaces on the same DVB network.

The INT allows both fully-specified IP addresses and prefix matching to reduce the size of table (and hence enhance signalling efficiency). An IPv4/IPv6 "subnet mask" may be given in full form or in slash notation (e.g. /127).

IP multicast addresses can be specified with or without a source (address or range), although if a source address is specified, then only the slash notation may be used for prefixes.

In addition to identification and security descriptors, the following descriptors are defined for address binding in INT tables:

(i) target_MAC_address_descriptor: The descriptor used to describe a single or set of MAC addresses (and their mask).

(ii) target_MAC_address_range_descriptor: May be used to set filters.

(iii) target_IP_address_descriptor: The descriptor describing a single or set of IPv4 unicast or multicast addresses (and their mask).

(iv) target_IP_slash_descriptor: Allows definition and announcement of an IPv4 prefix.

(v) target_IP_source_slash_descriptor: Uses source and destination addresses to target a single or set of systems.

(vi) IP/MAC stream_location_descriptor: This descriptor locates an IP/MAC stream in a DVB network.

The following descriptors provide corresponding functions for IPv6 addresses:

target_IPv6_address_descriptor
target_IPv6_slash_descriptor
and target_IPv6_source_slash_descriptor

The ISP_access_mode_descriptor allows specification of a second address descriptor to access an ISP via an alternative non-DVB (possibly non-IP) network.

The INT provides a set of descriptors to specify addressing in a DVB network. One key benefit is that the approach follows the MPEG-2 signaling methods and is integrated with the other signalling information. This allows the INT to operate in the presence of (re)multiplexors [ipdvb-arch] and refer to PID values that are carried within a number of different TS Multiplexes. This makes it well-suited to a Broadcast TV Scenario [ipdvb-arch].

The principle drawbacks are that while the INT, there is a need for a Gateway to introduce associated PSI/SI MPEG-2 control information. This control information also needs to be processed at the receiver below the IP layer, and the position of this processing within the protocol stack makes it hard to associate the results with IP Policy, management and security functions. The use of centralized management prevents the implementation of a more dynamic scheme. The method is currently defined only for Multi-Protocol Encapsulation

(MPE) and would need extension to support other schemes.

4.2.2 Multicast Mapping Table (MMT) and its usage

The Multicast Mapping Table (MMT) is an MPEG-2 level control table to that associates a set of multicast addresses with the corresponding PID values. This table allows a DVB-RCS Forward Link Subsystem (FLSS) to specify the mapping of IPv4 addresses to PID values within a specific TS Multiplex. Receivers (DVB-RCS Return Channel Satellite Terminals, RCSTs) may use this table to determine the PID values associated with an IP multicast flow that it requires to receive. The MMT is not currently a part of the DVB-RCS specification.

4.2.3 Application Information Table (AIT) and its usage

The DVB Multimedia Home Platform (MHP) specification does not define a specific AR function. However, the MHP Standard specifies an Application Information Table (AIT) that allows MHP Receivers to receive a variety of control information. The AIT uses a DSMCC format table providing information about data broadcasts, the required activation state of applications carried by a broadcast stream, etc. This information allows a broadcaster to request that a Receiver change the activation state of an application, and to direct applications to receive specific multicast packet flows (using IPv4 or IPv6 descriptors). In MHP, AR is not seen as a specific function, but as a part of a wider configuration and control function.

4.2.4 Comparison of SI/PSI table approaches

The MPEG-2 methods based on SI/PSI meet the specified requirements of the groups that created them and all have their strength: the INT in terms of flexibility and extensibility, the MMT in its simplicity, the AIT in its extensibility. However, they exhibit scalability constraints, encourage the development of technology specific solutions and do not fully adopt IP-centric approaches that would enable easier use of the MPEG-2 bearer as a link technology within the wider Internet.

4.3 IP-based resolution of TS Logical Channels

As MPEG-2 transmission networks evolve to become multiservice networks, the use of IP protocols is becoming more prevalent. Most MPEG-2 networks now use some IP protocols for operations, control and data delivery, transmission using IP packets could also be used for address resolution. The advantages of using a IP-based address resolution for TS streams include:

(i) Simplicity:

The AR mechanism does not require interpretation of Layer 2 tables; this is an advantage especially in the growing market share for home network and audio video networked entities.

(ii) Uniformity:
An IP-based protocol can provide a common method across different network scenarios for IP/MAC address mappings to TS Logical Channels (PID Values).

(iii) Extensibility:
IP-based AR mechanisms allow an independent evolution of the AR protocol. This includes dynamic methods to request address resolution and the ability to include other L2 information (e.g. Encryption keys).

(iv) Integration
The information exchanged by IP-based AR protocols can easily be integrated as a a part of the IP network layer, simplifying support for AAA, policy, OAM, mobility, configuration control, etc. that combine AR with security.

Drawbacks of an IP-based method include:

One drawback of IP-based AR is that this method can not operate over an MPEG-2 Transmission Network that uses remultiplexors [ipdvb-arch] to modify the PID values of the TS Logical Channels during the multiplexing operation. This makes the method unsuitable for use in deployed broadcast TV networks [ipdvb-arch].

IP-based methods can also introduce concerns about the integrity of the information and authentication of the sender [ipdvb-arch] (These concerns are also applicable to MPEG-2 table methods, but in this case the information is confined to the L2 network, or parts of the network where gateway devices isolate the MPEG devices from the larger Internet creating virtual MPEG2 private networks.) IP-based solutions should therefore implement security mechanisms that may be used to authenticate the sender and verify the integrity of the AR information, as a part of a larger security framework.

4.3.1 IP-based multicast resolution of TS Logical Channels

AR resolution must also be performed to associate the IP multicast Group Destination Address with an MPEG-2 layer TS Logical Channel (PID) and TS Multiplex. Solutions have been described in 4.2 to perform this below the IP layer using MPEG-2 Tables. Such methods currently perform a direct mapping (where a single address or set of addresses are associated with a specific PID value).

There is an opportunity to define an IP-level method that could use an IP multicast protocol over a well-known IP multicast address.

Scalability is an important feature of any multicast AR protocol, methods that employ prefix matching (e.g. where a range of source/destination addresses are matched to a single entry are desirable), but so also are methods that allow a range of addresses to mapped to a set of TS Logical Channels (similar to the mapping of IP Group Destination Addresses to Ethernet MAC addresses).

5. Mapping IP addresses to NPA/MAC addresses

This section reviews IETF protocols that may be used to assign and manage the mapping of IP addresses to/from NPA/MAC addresses.

IP Encapsulation Gateways may require AR information to select an appropriate MAC/NPA address in the SNDU header [ipdvb-arch] (see also section 6). The information to complete this header may be taken directly from a neighbour/arp cache, or may require the Gateway to retrieve the information using an AR protocol. The way in which this information is collected will depend upon whether the Gateway functions as a Router (at L3) or a Bridge (at L2).

Two IETF-defined protocols for mapping IP addresses to NPA/MAC addresses are ARP [RFC-ARP] and NDP [RFC-ND] for IPv4 and IPv6 respectively. Both protocols are normally used in a bi-directional mode, although both also permit unsolicited transmission of mappings. The mapping defined in [RFC2464] may result in use of a large number of L2 MAC addresses.

ARP requires support for L2 broadcast packets.

<< inputs requested on ARP scalability to large receiver groups >>

<< inputs requested on ARP security for wireless networks >>

<< inputs requested on ARP scoping when supporting multiple ISPs >>

The NDP uses a set of IP multicast addresses. In large networks, many multicast addresses are likely to be used, although little traffic is likely to be sent in each group. The AR multicast mechanism therefore needs to be able to support this in a scalable manner (see section XXX).

<< inputs requested on NDP scalability to large receiver groups >>

<< inputs requested on NDP security for wireless networks >>

<< inputs requested on NDP scoping when supporting multiple ISPs >>

5.1 Uni-directional links supporting uni-directional connectivity

Most MPEG-2 Transmission Networks provide a Uni-Directional broadcast link (UDL), with no return path. Such links may be used for unicast applications that do not require a return path (e.g.

based on UDP), but are more commonly used for IP multicast content distribution.

```
                                    ,-----.
                  MPEG-2 uplink    /MPEG-2 \
               *##################( Network )
               #                   \       /
          +----*------+             `--.--'
          |  Network  |                |
          |  Provider +                v MPEG-2 downlink
          +-----------+                |
                                 +-----v------+
                                 |   MPEG-2   |
                                 |  Receiver  |
                                 +------------+
```

Figure XX: Uni-directional connectivity

Although ARP and NDP may both operate in an unsolicited/promiscuous mode where they advertise information to the remote nodes, this does not provide an appropriate method to resolve the remote (destination) address in a uni-directional environment. To perform this task, these protocols require bi-directional L2/L3 connectivity.

<< inputs required on receiver address assignment in this case >>

5.2 Uni-directional links with bi-directional connectivity

Bi-directional connectivity may be realised using a pair of uni-directional in combination with another network path. Common combinations are a Feed link using MPEG-2 satellite transmission and a return link using terrestrial network infrastructure. This topology is often known as a Hybrid network, and has asymmetric network routing. It also often exhibits asymmetric network capacity [RFC-ASYM].

```
                                    ,-----.
                  MPEG-2 uplink    /MPEG-2 \
               *##################( Network )
               #                   \       /
          +----*------+             `--.--'
          |  Network  |                |
          |  Provider +-<-+            v MPEG-2 downlink
          +-----------+   |            |
                          |      +-----v------+
                          +--<<--+   MPEG-2   |
                        uplink   |  Receiver  |
                                 +------------+
```

Figure XX: Bi-directional connectivity

The Uni-Directional Link Routing, UDLR [RFC3077] protocol may be used to overcome the routing issues associated with asymmetric routing. UDLR provides a L2 tunnelling mechanism that emulates a bi-directional broadcast link at L2. The uni-directional routing is hidden from IP and upper layer protocols.

This section introduces how to use UDLR link layer tunnelling mechanisms to use ARP and ND on Uni-Directional DVB links.

<<< Will be completed later, inputs required from WG >>>

5.3 Bi-directional links

Bi-directional IP networks can be and are constructed by a combination of two MPEG-2 transmission links. The combined link functions as a full duplex interface. Examples of this use include two-way DVB-S satellite links and the DVB-RCS system.

<<< text on DHCP, L2TP, PPoE, etc to be added by other volunteers >>>

5.4 IP Multicast AR

This section describes the case where the destination network layer address is an IP multicast Group Destination Address.

In MPE [DVB-DAT], the mapping of IP multicast addresses to MAC/NPA addresses follows normal practice for IEEE MAC Addresses when using IPv4 and IPv6. (A variant of DVB (DVB-H) uses a modified MAC header [DVB_DAT]).

In ULE [ID-IPDVB-ULE], the L2 NPA address is optional, and is not necessarily required when the Receiver is able to perform efficient L3 multicast address filtering. When present, it follows the mapping of MPE and many other L2 link technologies.

6. Link Layer Support

This section considers layer 2 support for address resolution. It considers two issues that need to be considered. One is the code-point to be used at L2 and the other is the efficiency of encapsulation for transmission to utilise the AR method. The table below summarises the options for both MPE and ULE encapsulations.

L2 Encapsulation	PDU overhead [bytes]	L2 Frame Header Fields		
		src mac	dst mac	type
6.1 ULE without dst MAC address	8	-	-	x
6.2 ULE with dst MAC address	14	-	x	x
6.3 MPE without LLC/SNAP	16	-	x	-
6.4 MPE with LLC/SNAP	24	-	x	x
6.5 ULE with Bridging extension	22	x	x	x
6.6 ULE with Bridging & NPA	28	x	x	x
6.7 MPE+LLC/SNAP+Bridging	38	x	x	x

Table of L2 support and overhead (x=supported, -=not supported)

The remainder of the section describes IETF-specified AR methods for use with these encapsulation formats.

6.1 ULE without a destination MAC/NPA address (D=1)

The ULE encapsulation supports a mode (D=1) where the NPA/MAC address is not present in the encapsulated frame. This mode may be used with both IPv4 and IPv6. When this mode is used, the Receiver is expected to perform network-layer filtering of packets based on their IP destination address. Encapsulation Gateways must ensure that packets are associated with a TS Logical Channel (PID value) that uniquely identifies the intended recipient [IP-IPDVB-ULE]. This requires careful consideration of the network topology when used as a link between IP routers (a simple case where this is permitted is the connection of stub networks).

Since there is no MAC/NPA address in the SNDU, ARP and NDP are not required.

Note, since IPv6 systems can (and usually do) automatically configure their IPv6 network address based upon a local MAC address, the IP driver at the Receiver may still need to access the MAC/NPA address of the receiving interface.

6.2 ULE with a destination NPA/MAC address (D=0)

The IPv4 Address Resolution Protocol (ARP) [RFC826] uses an IANA-assigned EtherType and may be used over a link that supports ULE [IP-IPDVB-ULE]. Although no MAC source address is present in the SNDU, the protocol still communicates the source MAC address in the ARP record payload of any query messages that it generates.

The ND protocol of IPv6 [RFC2461] may be used.NDP does not require specification of a MAC source address, although this is required for a node to participate in Duplicate Address Detection (DAD).

<< More info on use of ND is required, also on usage of DAD and SEND>>

6.3 MPE without LLC/SNAP Encapsulation

This is the default (and sometimes only) mode specified by most MPE Encapsulation Gateways.

MPE does not provide an IANA-assigned EtherType and therefore can not support the Address Resolution Protocol (ARP) [RFC826].

IPv6 is not supported in this encapsulation format, and therefore it is not appropriate to consider the NDP.

6.4 MPE with LLC/SNAP Encapsulation

The LLC/SNAP format of MPE provides an IANA-assigned EtherType and therefore may support the Address Resolution Protocol (ARP) [RFC826]. There is no specification to define how this is performed. No MAC source address is present in the SNDU, although the protocol still communicates the source MAC address in the ARP record payload of any query messages that it generates.

The ND protocol of IPv6 [RFC2461] may be used with The LLC/SNAP format of MPE. NDP does not require specification of a MAC source address, although this is required for a node to participate in Duplicate Address Detection (DAD).

<< More info on use of ND is required, also on usage of DAD and SEND>>

6.5 ULE with Bridging Header Extension (D=1)

The ULE encapsulation supports a bridging extension header that supplies both a source and destination MAC address. This can be used without an NPA address (D=1). When no other Extension Headers are present, the MAC destination address has the same position in the ULE SNDU as that used for an NPA destination address. The Receiver may optionally be configured so that MAC destination address value is identical to the Receiver NPA address.

At the Encapsulation Gateway, the ULE NPA/MAC destination address is determined by a L2 forwarding decision. Received frames may be forwarded or may be addressed to the Receiver itself. As in other L2 LANs, the Receiver may choose to filter received frames based on a configured MAC destination address filter.

ARP messages may be carried within a PDU that is bridged by this encapsulation format.

The NDP messages may be carried within an IPv6 PDU that is bridged by this encapsulation format.

6.6 ULE with Bridging Header Extension and NPA Address (D=0)

The combination of a NPA address (D=0) and a bridging extension header are allowed in ULE. This SNDU format supplies both a source and destination MAC address and a NPA destination address (i.e. Receiver NPA/MAC address).

At the Encapsulation Gateway, the ULE NPA/MAC destination address is determined by a L2 forwarding decision. Received frames may be forwarded or may be addressed to the Receiver itself. As in other L2 LANs, the Receiver may choose to filter received frames based on a configured MAC destination address filter.

An ARP message may be carried within a PDU that is bridged by this encapsulation format.

An NDP message may be carried within an IPv6 PDU that is bridged by this encapsulation format.

6.7 MPE+LLC/SNAP+Bridging

The LLC/SNAP format MPE frames may optionally support an IEEE bridging header [LLC]. This header supplies both a source and destination MAC address, at the expense of larger encapsulation overhead. This format defines two MAC destination addresses, one associated with the MPE SNDU (i.e. Receiver MAC address) and one with the bridged MAC frame (i.e. the MAC address of the intended recipient in the remote LAN). At the Encapsulation Gateway, the MPE MAC destination address is determined by a L2 forwarding decision. As in other L2 LANs, the Receiver may choose to filter received frames based on a configured MAC destination address filter.

At the Encapsulation Gateway, the MPE MAC destination address is determined by a L2 forwarding decision. Received frames may be forwarded or may be addressed to the Receiver itself. As in other L2 LANs, the Receiver may choose to filter received frames based on a configured MAC destination address filter.

An ARP message may be carried within a PDU that is bridged by this encapsulation format.

An NDP message may be carried within an IPv6 PDU that is bridged by this encapsulation format. The MPE MAC destination address is determined by a L2 forwarding decision.

7. Conclusions

This document has described addressing and address resolution issues concerning the use of IP protocols over MPEG-2 transmission networks. A number of specific IETF protocols are discussed along with their expected behaviour over MPEG-2 transmission networks and recommendations for usage.

In current MPEG-2 networks, a static binding may be configured for IP addresses and PIDs (as in some cable networks). This information may also be provided by the Gateway/Multiplexor and carried in tables (e.g. AIT in MHP, the IP Notification Table, INT, of DVB and the DVB-RCS Multicast Mapping Table, MMT). This document has reviewed the status of these current address resolution mechanisms in MPEG-2 transmission networks, defined their usage and provided information to identify what would be needed to improve their support for IP protocols.

8. Security Considerations

The normal security issues relating to the use of wireless links for transport Internet traffic should be considered. Readers are also referred to the known security issues associated with ARP [RFC826] and ND [RFC-ND].

9. Acknowledgments

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12. IPR Notices

12.1 Intellectual Property Statement

12.2 Disclaimer of Validity

13. Copyright Statement

14. IANA Considerations

NOT KNOWN AT THIS TIME.

APPENDICES

[>>> NOTE to RFC Editor: Please remove this appendix prior to publication]

APPENDIX A: Document History

-00 This draft is intended as a study item for proposed future work by the IETF in this area.
-01 Review of initial content, major edit and refinement of concepts
-02 fairly important review; took out all new protocol reference; added one author; added contribution on real implementation
-02 Added content to respond to 61st IETF comments; refined ID goals; rewrote section 4.2 and 4.3; added cable information.
-03 Major reorganise to align with Charter, and clearly identify IP issues.
-04 restructured the draft (major rewrite) and added discussion of arp and ND related to specific cases for use.

[>>> NOTE to RFC Editor: End of appendix]

APPENDIX B: Candidate IP-based L2 AR Protocols

This appendix contains a list of candidate protocols for "above IP" AR. None of these protocols currently support the AR methods required for MPEG-2 Transmission Networks. Specifically they do not all support:

(i) Resolution of Addresses to TS Logical Channels
(ii) Resolution of multiple addresses in a single AR update message (table-based).
(iii) Multicast transport.

Candidate protocols include:

ARP <extension required>
- IPv4 only.
- No table support <could be added>
- Support for versioning within current implementations not clear.
- Broadcast mode has drawbacks.
- No obvious support for scoping to multiple addressing domains.

ND <extension required>
- IPv6 only.
- No table support <could be added>
- Use multicast address.
- No obvious support for scoping to multiple addressing domains.

DTCP [RFC3077] <extension required>
- IPv4 and IPv6.
- Table support seems natural.
- Uses multicast address.
- Need to consider scoping for multiple addressing domains.
- Not really an IP AR protocol
- Already used on some (UDLR) links - and this new use seems complementary.

AR/IP <new protocol required>
- IPv4 and IPv6.
- Based on UDP or at network-layer.
- Could use multicast address.
- Table support possible.
- New protocol format.
- Could add scoping for multiple addressing domains.

XML/foo/IP <new protocol required>
- IPv4 and IPv6.
- Based on UDP or at network-layer or an XML transport (which?).
- Could use multicast address.
- Table support seems natural.

- New protocol format.
- Could add scoping for multiple addressing domains.
- Extensible/flexible to other configuration data (if required).

- Compression of XML required to achieve efficiency comparable with other methods.

<<<<