             Multiprotocol Encapsulation over ATM Adaptation Layer 5

Status of this Memo

Abstract

   This memo describes two encapsulations methods for carrying network
   interconnect traffic over ATM AAL5. The first method allows
   multiplexing of multiple protocols over a single ATM virtual circuit
   whereas the second method assumes that each protocol is carried over
   a separate ATM virtual circuit.

1. Introduction

   Asynchronous Transfer Mode (ATM) based networks are of increasing
   interest for both local and wide area applications. This memo
   describes two different methods for carrying connectionless network
   interconnect traffic, routed and bridged Protocol Data Units (PDUs),
   over an ATM network. The first method allows multiplexing of
   multiple protocols over a single ATM virtual circuit. The protocol
   of a carried PDU is identified by prefixing the PDU by an IEEE 802.2
   Logical Link Control (LLC) header. This method is in the following
   called "LLC Encapsulation" and a subset of it has been earlier
   defined for SMDS [1]. The second method does higher-layer protocol
   multiplexing implicitly by ATM Virtual Circuits (VCs). It is in the
   following called "VC Based Multiplexing".

   ATM is a cell based transfer mode that requires variable length user
   information to be segmented and reassembled to/from short, fixed
   length cells. This memo doesn't specify a new Segmentation And
   Reassembly (SAR) method for bridged and routed PDUs. Instead, the
   PDUs are carried in the Payload field of Common Part Convergence
   Sublayer (CPCS) PDU of ATM Adaptation Layer type 5 (AAL5) [2].

   Note that this memo only describes how routed and bridged PDUs are
   carried directly over the CPCS of AAL5, i.e., when the Service
   Specific Convergence Sublayer (SSCS) of AAL5 is empty. If Frame

Relay Service Specific Convergence Sublayer (FR-SSCS), as defined in
I.36x.1 [3], is used over the CPCS of AAL5, then routed and bridged
PDUs are carried using the NLPID multiplexing method described in RFC
1294 [4]. Appendix A (which is for information only) shows the
format of the FR-SSCS-PDU as well as how IP and CLNP PDUs are
encapsulated over FR-SSCS according to RFC 1294.

2. Selection of the Multiplexing Method

It is envisioned that VC Based Multiplexing will be dominant in
environments where dynamic creation of large numbers of ATM VCs is
fast and economical. These conditions are likely to first prevail in
private ATM networks. LLC Encapsulation, on the other hand, may be
desirable when it is not practical for one reason or another to have
a separate VC for each carried protocol. This is the case, for
example, if the ATM network only supports (semi) Permanent Virtual
Circuits (PVCs) or if charging depends heavily on the number of
simultaneous VCs.

When two ATM stations wish to exchange connectionless network
interconnect traffic, selection of the multiplexing method is done
either by manual configuration (in case of PVCs) or by B-ISDN
signalling procedures (in case of Switched VCs). The details of B-
ISDN signalling are still under study in CCITT [5]. It can, however,
be assumed that B-ISDN signalling messages include a "Low layer
compatibility" information element, which will allow negotiation of
AAL5 and the carried (encapsulation) protocol.

3. AAL5 Frame Format

No matter which multiplexing method is selected, routed and bridged
PDUs shall be encapsulated within the Payload field of AAL5 CPCS-PDU.
The format of the AAL5 CPCS-PDU is given below:

```
              AAL5 CPCS-PDU Format
         +------------------------------+
         |               .              |
         |               .              |
         |        CPCS-PDU Payload       |
         |      up to 2^16 - 1 octets)   |
         |               .              |
         |               .              |
         +------------------------------+
         |      PAD ( 0 - 47 octets)    |
         +------------------------------+ -------
         |      CPCS-UU (1 octet )      |
         +------------------------------+
         |        CPI (1 octet )        |
         +------------------------------+CPCS-PDU Trailer
         |      Length (2 octets)       |
         +------------------------------|
         |        CRC (4 octets)        |
         +------------------------------+ -------
```
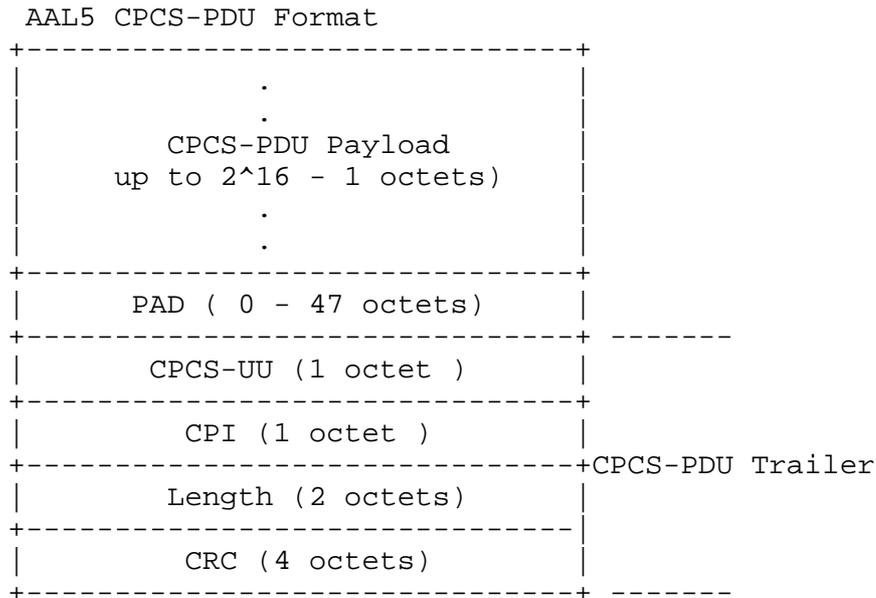
The Payload field contains user information up to 2^16 - 1 octets.

The PAD field pads the CPCS-PDU to fit exactly into the ATM cells
such that the last 48 octet cell payload created by the SAR sublayer
will have the CPCS-PDU Trailer right justified in the cell.

The CPCS-UU (User-to-User indication) field is used to transparently
transfer CPCS user to user information. The field has no function
under the multiprotocol ATM encapsulation described in this memo and
can be set to any value.

The CPI (Common Part Indicator) field alings the CPCS-PDU trailer to
64 bits. Possible additional functions are for further study in
CCITT. When only the 64 bit alignment function is used, this field
shall be codes as 0x00.

The Length field indicates the length, in octets, of the Payload
field. The maximum value for the Length field is 65535 octets. A
Length field coded as 0x00 is used for the abort function.

The CRC field protects the entire CPCS-PDU except the CRC field
itself.

4. LLC Encapsulation

   LLC Encapsulation is needed when several protocols are carried over
   the same VC. In order to allow the receiver to properly process the
   incoming AAL5 CPCS-PDU, the Payload Field must contain information

necessary to identify the protocol of the routed or bridged PDU. In
LLC Encapsulation this information is encoded in an LLC header placed
in front of the carried PDU.

Although this memo only deals with protocols that operate over LLC
Type 1 (unacknowledged connectionless mode) service, the same
encapsulation principle applies also to protocols operating over LLC
Type 2 (connection-mode) service. In the latter case the format
and/or contents of the LLC header would differ from what is shown
below.

4.1. LLC Encapsulation for Routed Protocols

In LLC Encapsulation the protocol of the routed PDU is identified by
prefixing the PDU by an IEEE 802.2 LLC header, which is possibly
followed by an IEEE 802.1a SubNetwork Attachment Point (SNAP) header.
In LLC Type 1 operation, the LLC header consists of three one octet
fields:

```
        +------+------+------+
        | DSAP | SSAP | Ctrl |
        +------+------+------+
```

In LLC Encapsulation for routed protocols, the Control field has
always value 0x03 specifying Unnumbered Information Command PDU.

The LLC header value 0xFE-FE-03 identifies that a routed ISO PDU (see
[6] and Appendix B) follows. The Control field value 0x03 specifies
Unnumbered Information Command PDU. For routed ISO PDUs the format
of the AAL5 CPCS-PDU Payload field shall thus be as follows:

```
        Payload Format for Routed ISO PDUs
    +------------------------------+
    |        LLC   0xFE-FE-03       |
    +------------------------------+
    |              .               |
    |           ISO PDU            |
    |     (up to 2^16 - 4 octets)  |
    |              .               |
    +------------------------------+
```

The routed ISO protocol is identified by a one octet NLPID field that
is part of Protocol Data. NLPID values are administered by ISO and
CCITT. They are defined in ISO/IEC TR 9577 [6] and some of the
currently defined ones are listed in Appendix C.

An NLPID value of 0x00 is defined in ISO/IEC TR 9577 as the Null
Network Layer or Inactive Set. Since it has no significance within

the context of this encapsulation scheme, a NLPID value of 0x00 is
invalid under the ATM encapsulation.

It would also be possible to use the above encapsulation for IP,
since, although not an ISO protocol, IP has an NLPID value 0xCC
defined for it. This format must not be used. Instead, IP is
encapsulated like all other routed non-ISO protocols by identifying
it in the SNAP header that immediately follows the LLC header.

The presence of a SNAP header is indicated by the LLC header value
0xAA-AA-03. A SNAP header is of the form

```
            +------+------+------+------+------+
            |       OUI          |    PID     |
            +------+------+------+------+------+
```

The three-octet Organizationally Unique Identifier (OUI) identifies
an organization which administers the meaning of the following two
octet Protocol Identifier (PID). Together they identify a distinct
routed or bridged protocol. The OUI value 0x00-00-00 specifies that
the following PID is an EtherType.

The format of the AAL5 CPCS-PDU Payload field for routed non-ISO PDUs
shall thus be as follows:

```
            Payload Format for Routed non-ISO PDUs
            +-------------------------------+
            |      LLC  0xAA-AA-03           |
            +-------------------------------+
            |      OUI 0x00-00-00           |
            +-------------------------------+
            |    EtherType (2 octets)       |
            +-------------------------------+
            |               .               |
            |         Non-ISO PDU           |
            |      (up to 2^16 - 9 octets)  |
            |               .               |
            +-------------------------------+
```

In the particular case of an Internet IP PDU, the Ethertype value is
0x08-00:

```
              Payload Format for Routed IP PDUs
              +------------------------------+
              |       LLC  0xAA-AA-03        |
              +------------------------------+
              |        OUI 0x00-00-00        |
              +------------------------------+
              |      EtherType 0x08-00       |
              +------------------------------+
              |               .              |
              |            IP PDU            |
              |     (up to 2^16 - 9 octets)  |
              |               .              |
              +------------------------------+
```
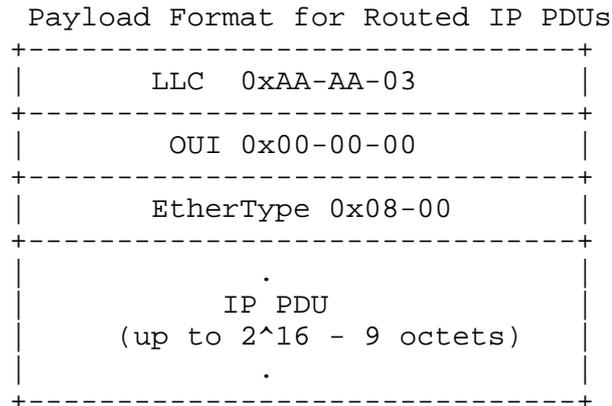
This is compatible with RFC 1042 [7]. Any changes in the header
format specified in RFC 1042 should be followed by this memo.

4.2. LLC Encapsulation for Bridged Protocols

In LLC Encapsulation bridged PDUs are encapsulated by identifying the
type of the bridged media in the SNAP header. As with routed non-ISO
protocols, the presence of the SNAP header is indicated by the LLC
header value 0xAA-AA-03. With bridged protocols the OUI value in the
SNAP header is the 802.1 organization code 0x00-80-C2 and the actual
type of the bridged media is specified by the two octet PID.
Additionally, the PID indicates whether the original Frame Check
Sequence (FCS) is preserved within the bridged PDU. The media type
(PID) values that can be used in ATM encapsulation are listed in
Appendix B.

The AAL5 CPCS-PDU Payload field carrying a bridged PDU shall,
therefore, have one of the following formats. Padding is added after
the PID field if necessary in order to align the user information
field of the bridged PDU at a four octet boundary.

Payload Format for Bridged Ethernet/802.3 PDUs

```
+-----------------------------+
|      LLC   0xAA-AA-03       |
+-----------------------------+
|       OUI 0x00-80-C2        |
+-----------------------------+
|    PID 0x00-01 or 0x00-07   |
+-----------------------------+
|        PAD 0x00-00          |
+-----------------------------+
|   MAC destination address   |
+-----------------------------+
|                             |
|   (remainder of MAC frame)  |
|                             |
+-----------------------------+
|  LAN FCS (if PID is 0x00-01)|
+-----------------------------+
```

Payload Format for Bridged 802.4 PDUs

```
+-----------------------------+
|      LLC   0xAA-AA-03       |
+-----------------------------+
|       OUI 0x00-80-C2        |
+-----------------------------+
|    PID 0x00-02 or 0x00-08   |
+-----------------------------+
|        PAD 0x00-00-00       |
+-----------------------------+
|    Frame Control (1 octet)  |
+-----------------------------+
|   MAC destination address   |
+-----------------------------+
|                             |
|   (remainder of MAC frame)  |
|                             |
+-----------------------------+
|  LAN FCS (if PID is 0x00-02)|
+-----------------------------+
```
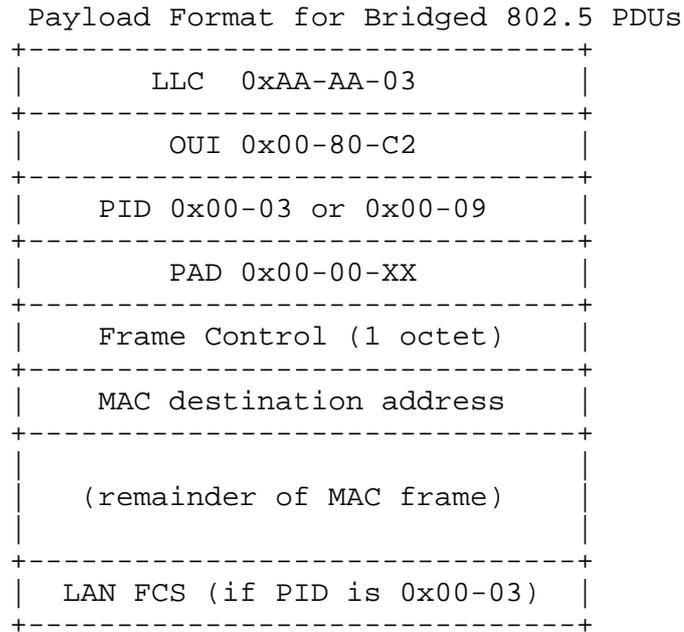
```
        Payload Format for Bridged 802.5 PDUs
        +------------------------------+
        |       LLC   0xAA-AA-03       |
        +------------------------------+
        |       OUI 0x00-80-C2         |
        +------------------------------+
        |   PID 0x00-03 or 0x00-09     |
        +------------------------------+
        |       PAD 0x00-00-XX         |
        +------------------------------+
        |    Frame Control (1 octet)   |
        +------------------------------+
        |   MAC destination address    |
        +------------------------------+
        |                              |
        |   (remainder of MAC frame)   |
        |                              |
        +------------------------------+
        |  LAN FCS (if PID is 0x00-03) |
        +------------------------------+
```

Note that the 802.5 Access Control (AC) field has no significance
outside the local 802.5 subnetwork. It can thus be regarded as the
last octet of the three octet PAD field, which can be set to any
value (XX).

```
        Payload Format for Bridged FDDI PDUs
        +------------------------------+
        |       LLC   0xAA-AA-03       |
        +------------------------------+
        |       OUI 0x00-80-C2         |
        +------------------------------+
        |   PID 0x00-04 or 0x00-0A     |
        +------------------------------+
        |       PAD 0x00-00-00         |
        +------------------------------+
        |    Frame Control (1 octet)   |
        +------------------------------+
        |   MAC destination address    |
        +------------------------------+
        |                              |
        |   (remainder of MAC frame)   |
        |                              |
        +------------------------------+
        |  LAN FCS (if PID is 0x00-04) |
        +------------------------------+
```

```
              Payload Format for Bridged 802.6 PDUs
              +------------------------------+
              |      LLC   0xAA-AA-03         |
              +------------------------------+
              |       OUI 0x00-80-C2          |
              +------------------------------+
              |        PID 0x00-0B            |
              +--------------+---------------+ ------
              |   Reserved   |    BEtag      | Common
              +--------------+---------------+ PDU
              |           BAsize             | Header
              +------------------------------+ -------
              |   MAC destination address    |
              +------------------------------+
              |                              |
              |   (remainder of MAC frame)   |
              |                              |
              +------------------------------+
              |                              |
              |     Common PDU Trailer       |
              |                              |
              +------------------------------+
```

   Note that in bridged 802.6 PDUs, there is only one choice for the PID
   value, since the presence of a CRC-32 is indicated by the CIB bit in
   the header of the MAC frame.

   The Common Protocol Data Unit (PDU) Header and Trailer are conveyed
   to allow pipelining at the egress bridge to an 802.6 subnetwork.
   Specifically, the Common PDU Header contains the BAsize field, which
   contains the length of the PDU. If this field is not available to
   the egress 802.6 bridge, then that bridge cannot begin to transmit
   the segmented PDU until it has received the entire PDU, calculated
   the length, and inserted the length into the BAsize field. If the
   field is available, the egress 802.6 bridge can extract the length
   from the BAsize field of the Common PDU Header, insert it into the
   corresponding field of the first segment, and immediately transmit
   the segment onto the 802.6 subnetwork. Thus, the bridge can begin
   transmitting the 802.6 PDU before it has received the complete PDU.

   Note that the Common PDU Header and Trailer of the encapsulated frame
   should not be simply copied to the outgoing 802.6 subnetwork because
   the encapsulated BEtag value may conflict with the previous BEtag
   value transmitted by that bridge.

   An ingress 802.6 bridge can abort an AAL5 CPCS-PDU by setting its
   Length field to zero. If the egress bridge has already begun
   transmitting segments of the PDU to an 802.6 subnetwork and then

notices that the AAL5 CPCS-PDU has been aborted, it may immediately
generate an EOM cell that causes the 802.6 PDU to be rejected at the
receiving bridge. Such an EOM cell could, for example, contain an
invalid value in the Length field of the Common PDU Trailer.

```
            +------------------------------+
            |      LLC  0xAA-AA-03          |
            +------------------------------+
            |      OUI 0x00-80-C2           |
            +------------------------------+
            |      PID 0x00-0E              |
            +------------------------------+
            |                              |
            |      BPDU as defined by       |
            |     802.1(d) or 802.1(g)      |
            |                              |
            +------------------------------+
```
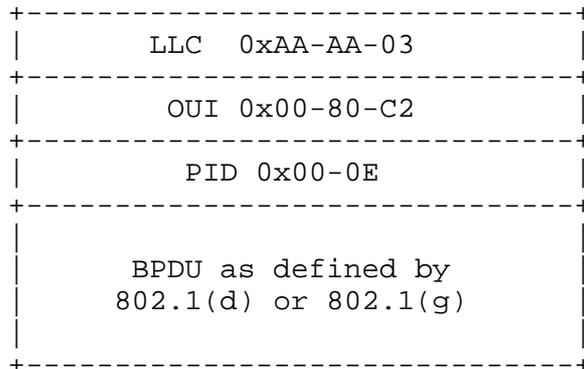
5. VC Based Multiplexing

   In VC Based Multiplexing, the carried network interconnect protocol
   is identified implicitly by the VC connecting the two ATM stations,
   i.e. each protocol must be carried over a separate VC. There is
   therefore no need to include explicit multiplexing information in the
   Payload of the AAL5 CPCS-PDU. This results in minimal bandwidth and
   processing overhead.

   As indicated above, the carried protocol can be either manually
   configured or negotiated dynamically during call establishment using
   signalling procedures. The signalling details will be defined later
   in other RFCs when the relevant standards have become available.

5.1. VC Based Multiplexing of Routed Protocols

   PDUs of routed protocols shall be carried as such in the Payload of
   the AAL5 CPCS-PDU. The format of the AAL5 CPCS-PDU Payload field
   thus becomes:

```
            Payload Format for Routed PDUs
            +------------------------------+
            |               .              |
            |          Carried PDU         |
            |      (up to 2^16 - 1 octets) |
            |               .              |
            |               .              |
            +------------------------------+
```
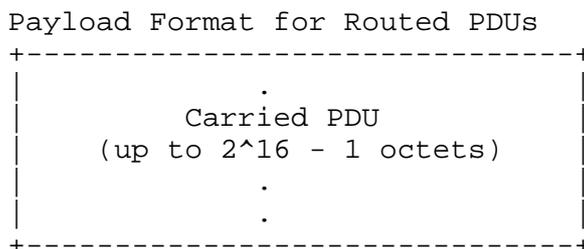
5.2. VC Based Multiplexing of Bridged Protocols

   PDUs of bridged protocols shall be carried in the Payload of the AAL5
   CPCS-PDU exactly as described in section 4.2 except that only the
   fields after the PID field are included. The AAL5 CPCS-PDU Payload
   field carrying a bridged PDU shall, therefore, have one of the
   following formats.

               Payload Format for Bridged Ethernet/802.3 PDUs
             +------------------------------+
             | PAD 0x00-00 |
             +------------------------------+
             | MAC destination address |
             +------------------------------+
             | |
             | (remainder of MAC frame) |
             | |
             +------------------------------+
             | LAN FCS (VC dependent option) |
             +------------------------------+

               Payload Format for Bridged 802.4/802.5/FDDI PDUs
             +------------------------------+
             | PAD 0x00-00-00 or 0x00-00-XX |
             +------------------------------+
             | Frame Control (1 octet) |
             +------------------------------+
             | MAC destination address |
             +------------------------------+
             | |
             | (remainder of MAC frame) |
             | |
             +------------------------------+
             | LAN FCS (VC dependent option) |
             +------------------------------+
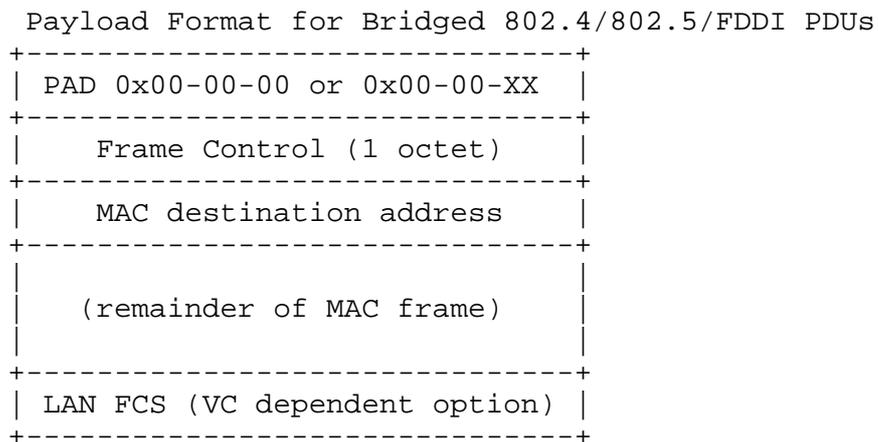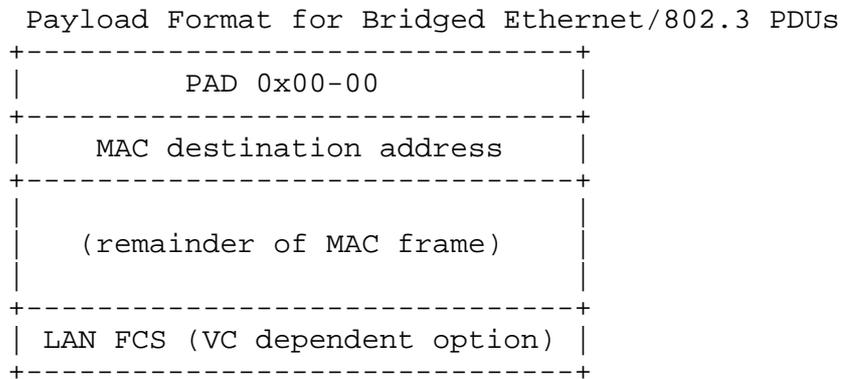
   Note that the 802.5 Access Control (AC) field has no significance
   outside the local 802.5 subnetwork. It can thus be regarded as the
   last octet of the three octet PAD field, which in case of 802.5 can
   be set to any value (XX).

```
              Payload Format for Bridged 802.6 PDUs
              +---------------+---------------+ -------
              |   Reserved    |     BEtag     | Common
              +---------------+---------------+ PDU
              |             BAsize            | Header
              +-------------------------------+ -------
              |     MAC destination address   |
              +-------------------------------+
              |                               |
              |   (remainder of MAC frame)    |
              |                               |
              +-------------------------------+
              |                               |
              |     Common PDU Trailer        |
              |                               |
              +-------------------------------+


              Payload Format for BPDUs
              +-------------------------------+
              |                               |
              |        BPDU as defined by     |
              |       802.1(d) or 802.1(g)    |
              |                               |
              +-------------------------------+
```
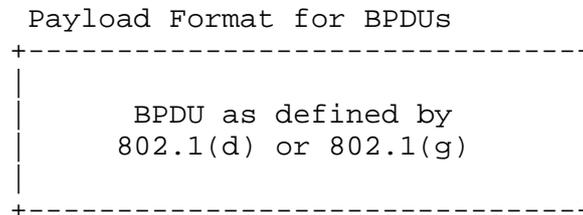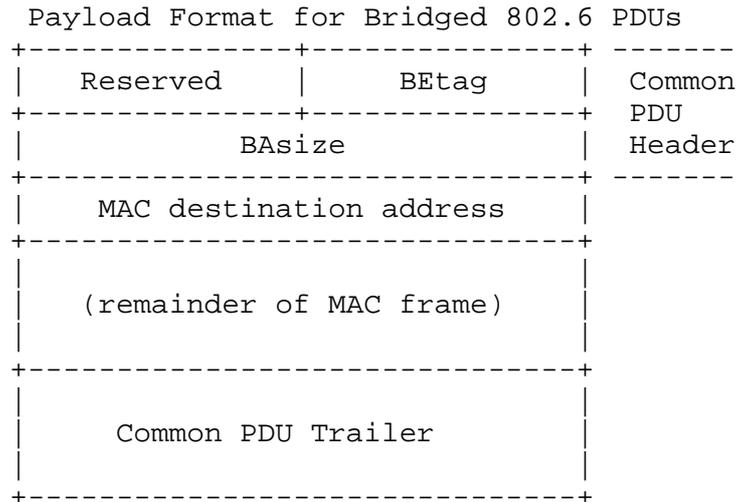
   In case of Ethernet, 802.3, 802.4, 802.5, and FDDI PDUs the presense
   or absence of the trailing LAN FCS shall be identified implicitly by
   the VC, since the PID field is not included. PDUs with the LAN FCS
   and PDUs without the LAN FCS are thus considered to belong to
   different protocols even if the bridged media type would be the same.

6. Bridging in an ATM Network

   An ATM interface acting as a bridge must be able to flood, forward,
   and filter bridged PDUs.

   Flooding is performed by sending the PDU to all possible appropriate
   destinations. In the ATM environment this means sending the PDU
   through each relevant VC. This may be accomplished by explicitly
   copying it to each VC or by using a multicast VC.

   To forward a PDU, a bridge must be able to associate a destination
   MAC address with a VC. It is unreasonable and perhaps impossible to
   require bridges to statically configure an association of every

   possible destination MAC address with a VC. Therefore, ATM bridges

must provide enough information to allow an ATM interface to
dynamically learn about foreign destinations beyond the set of ATM
stations.

To accomplish dynamic learning, a bridged PDU shall conform to the
encapsulation described within section 4. In this way, the receiving
ATM interface will know to look into the bridged PDU and learn the
association between foreign destination and an ATM station.

7. For Further Study

Due to incomplete standardization of ATM multicasting, addressing,
and signalling mechanisms, details related to the negotiation of the
multiplexing method as well as address resolution had to be left for
further RFCs.

Acknowledgements

This document has evolved from RFCs [1] and [4] from which much of
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C. Brown, A. Malis, D. Piscitello, and C. Lawrence. In addition,
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Joel Halpern of Network Systems, Bob Hinden of Sun Mircosystems, and
Gary Kessler of MAN Technology Corporation for their detailed
contributions.

Security Considerations

Security issues are not addressed in this memo.

References

    [1] Piscitello, D. and Lawrence, C., "The Transmission of IP
         Datagrams over the SMDS Service". RFC 1209, Bell Communications
         Research, March 1991.

    [2] CCITT, "Draft Recommendation I.363". CCITT Study Group XVIII,
         Geneva, 19 - 29 January, 1993.

    [3] CCITT, "Draft Recommendation I.36x.1". CCITT Study Group XVIII,
         Geneva, 19-29 January, 1993.

    [4] Bradley, T., Brown, C., and Malis, A., "Multiprotocol
         Interconnect over Frame Relay". RFC 1294, Wellfleet
         Communications, Inc. and BBN Communications, January 1992.

    [5] CCITT, "Draft text for Q.93B". CCITT Study Group XI, 23
         September - 2 October, 1992.

    [6] Information technology - Telecommunications and Information
         Exchange Between Systems, "Protocol Identification in the
         Network Layer". ISO/IEC TR 9577, October 1990.

    [7] Postel, J. and Reynolds, J., "A Standard for the Transmission of
         IP Datagrams over IEEE 802 Networks". RFC 1042, ISI, February,
         1988.

Appendix A. Multiprotocol Encapsulation over FR-SSCS

    I.36x.1 defines a Frame Relaying Specific Convergence Sublayer (FR-
    SSCS) to be used on the top of the Common Part Convergence Sublayer
    CPCS) of the AAL type 5 for Frame Relay/ATM interworking. The
    service offered by FR-SSCS corresponds to the Core service for Frame
   Relaying as described in I.233.

    An FR-SSCS-PDU consists of Q.922 Address field followed by Q.922
    Information field. The Q.922 flags and the FCS are omitted, since
    the corresponding functions are provided by the AAL. The figure
    below shows an FR-SSCS-PDU embedded in the Payload of an AAL5 CPCS-
    PDU.

```
            FR-SSCS-PDU in Payload of AAL5 CPCS-PDU
        +-------------------------------+ -------
        |       Q.922 Address Field     | FR-SSCS-PDU Header
        |          (2-4 octets)         |
        +-------------------------------+ -------
        |                .              |
        |                .              |
        |      Q.922 Information field  | FR-SSCS-PDU Payload
        |                .              |
        |                .              |
        +-------------------------------+ -------
        |      AAL5 CPCS-PDU Trailer    |
        +-------------------------------+
```
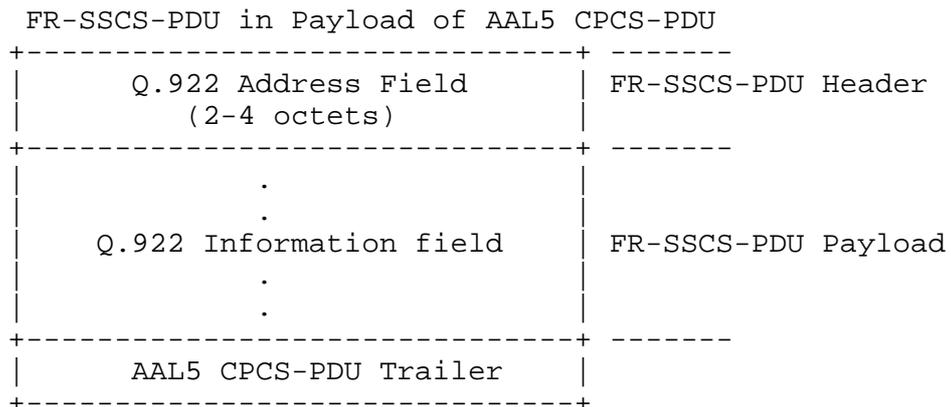
    Routed and bridged PDUs are encapsulated inside the FR-SSCS-PDU as
    defined in RFC 1294. The Q.922 Information field starts with a Q.922
    Control field followed by an optional Pad octet that is used to align
    the remainder of the frame to a convenient boundary for the sender.
    The protocol of the carried PDU is then identified by prefixing the
    PDU by an ISO/CCITT Network Layer Protocol ID (NLPID).

    In the particular case of an IP PDU, the NLPID is 0xCC and the FR-
   SSCS-PDU has the following format:

```
        FR-SSCS-PDU Format for Routed IP PDUs
        +------------------------------+
        |         Q.922 Addr Field     |
        |         (2 or 4 octets)      |
        +------------------------------+
        |     0x03 (Q.922 Control)     |
        +------------------------------+
        |         NLPID  0xCC          |
        +------------------------------+
        |               .              |
        |             IP PDU           |
        |      (up to 2^16 - 5 octets) |
        |               .              |
        +------------------------------+
```
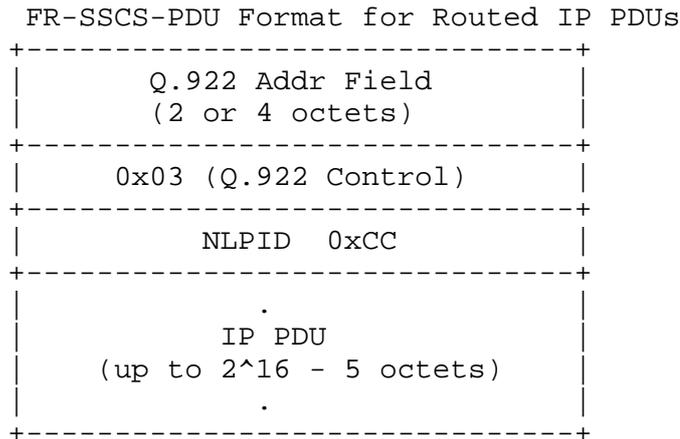
Note that according to RFC 1294 the Q.922 Address field shall be
either 2 or 4 octets, i.e., a 3 octet Address field is not supported.

In the particular case of a CLNP PDU, the NLPID is 0x81 and the FR-
SSCS-PDU has the following format:

```
        FR-SSCS-PDU Format for Routed CLNP PDUs
        +------------------------------+
        |         Q.922 Addr Field     |
        |         (2 or 4 octets)      |
        +------------------------------+
        |     0x03 (Q.922 Control)     |
        +------------------------------+
        |         NLPID  0x81          |
        +------------------------------+
        |               .              |
        |       Rest of CLNP PDU       |
        |      (up to 2^16 - 5 octets) |
        |               .              |
        +------------------------------+
```
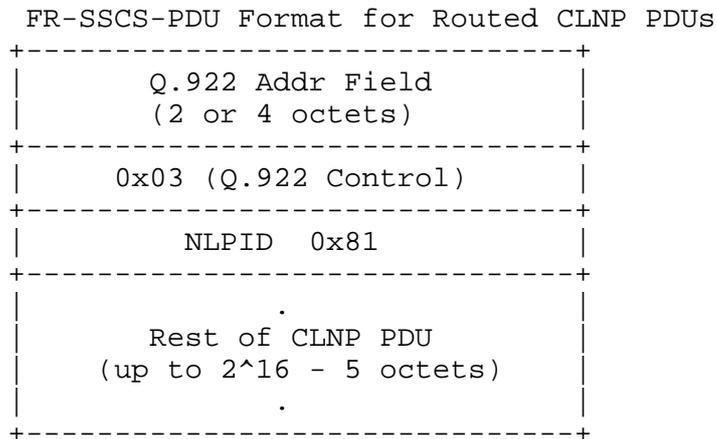
Note that in case of ISO protocols the NLPID field forms the first
octet of the PDU itself and shall thus not be repeated.

The above encapsulation applies only to those routed protocols that
have a unique NLPID assigned. For other routed protocols (and for
bridged protocols), it is necessary to provide another mechanism for
easy protocol identification. This can be achieved by using an NLPID
value 0x80 to indicate that an IEEE 802.1a SubNetwork Attachment
Point (SNAP) header follows.

See RFC 1294 for more details related to multiprotocol encapsulation
over FRCS.

Appendix B. List of Locally Assigned values of OUI 00-80-C2

with preserved FCS	w/o preserved FCS	Media
0x00-01	0x00-07	802.3/Ethernet
0x00-02	0x00-08	802.4
0x00-03	0x00-09	802.5
0x00-04	0x00-0A	FDDI
0x00-05	0x00-0B	802.6
	0x00-0D	Fragments
	0x00-0E	BPDUs

Appendix C. Partial List of NLPIDs

        0x00   Null Network Layer or Inactive Set (not used with ATM)
        0x80   SNAP
        0x81   ISO CLNP
        0x82   ISO ESIS
        0x83   ISO ISIS
        0xCC   Internet IP

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