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     Toshiba's Flow Attribute Notification Protocol (FANP) Specification

Status of this Memo

Abstract

   This memo discusses Flow Attribute Notification Protocol (FANP),
   which is a protocol between neighbor nodes for the management of
   cut-through packet forwarding functionalities. In cut-through packet
   forwarding, a router doesn't have to perform conventional IP packet
   processing for received packets. FANP indicates mapping information
   between a datalink connection and a packet flow to the neighbor node
   and helps a pair of nodes manage the mapping information. By using
   FANP, routers (e.g., CSR; Cell Switch Router) can forward incoming
   packets based on their datalink-level connection identifiers,
   bypassing usual IP packet processing. The design policy of the FANP
   is;

        (1) soft-state cut-through path (Dedicated-VC) management
        (2) protocol between neighbor nodes instead of end-to-end
        (3) applicable to any connection oriented datalink platform

1. Background

   Due to the scalability requirement, connection oriented (CO) datalink
   platforms, e.g., ATM and Frame Relay, are going to be used as well as
   connection less (CL) datalink platforms, e.g., Ethernet and FDDI.
   One of the important features of the CO datalink is the presence of a
   datalink-level connection identifier. In the CO datalink, we can
   establish multiple virtual connections (VCs) with their VC
   identifiers among the nodes. When we aggregate packets that have the
   same direction (e.g., having the same destination IP address) into a
   single VC, we can forward the packets in the VC without IP

processing. With this configuration, routers can decide which node
is the next-hop for the packets based on the VC identifier. CSRs [1]
can forward the incoming packets using an ATM switch engine bypassing
the conventional IP processing. According to the ingress VPI/VCI
value with ingress interface information, CSR determines the egress
interface and egress VPI/VCI value.

In order to configure the cut-through packet forwarding state, a pair
of neighbor nodes have to share the mapping information between the
packet flow and the datalink VC. FANP (Flow Attribute Notification
Protocol) described in this memo is the protocol to configure and
manage the cut-through packet forwarding state.

2. Protocol Requirements and Future Enhancement

2.1 Protocol Requirements

The followings are the protocol requirements for FANP.

(1) Applicable to various types of CO datalink platforms

(2) Available with various connection types (i.e., SVC, PVC, VP)

(3) Robust operation
    The system should operate correctly even under the following
    conditions.

  (a) VC failure
      Some systems can detect VC failure as the function of
      datalink (e.g., OAM function in the ATM). However, we can
      not assume all nodes in the system can detect VC failure.
      The system has to operate correctly, assuming that every
      node can not detect VC failure.

  (b) Message loss
      Control messages in the FANP may be lost. The system has to
      operate correctly, even when some control messages are lost.

  (c Node failure
      A node may be down without any explicit notification to its
      neighbors. The system has to operate correctly, even with
      node failure.

Though FANP is not the protocol only for ATM, the following
discussion assumes that the datalink is an ATM network.

2.2 Future Enhancement

   The followings are the future enhancements to be done.

        (1) Aggregated flow

           In this memo, we define the flow which contain source and
           destination IP address. As this may require many VC
           resources, we also need a new definition of aggregated flow
           which includes several end-to-end flows. The concrete
           definition of the aggregated flow is for future study.

        (2) Providing multicast service
        (3) Supporting IP level QOS signaling like RSVP
        (4) Supporting IPv6

3. Terminology and Definition

   o VCID (Virtual Connection IDentifier)
     Since VPI/VCI values at the origination and the termination points
     of a VC (and VP) may not be the same, we need an identifier to
     uniquely identify the datalink connection between neighbor nodes.
     We define this identifier as a VCID. Currently, only one type of
     VCID is defined. This VCID contains the ESI (End System
     Identifier) of a source node and the unique identifier within a
     source node.

   o Flow ID (Flow IDentifier)
     IP level packet flow is identified by some parameters in a packet.
     Currently, only one type of flow ID is defined. This flow ID
     contains a source IP address and a destination IP address. Note
     that flow ID used in this specification is not the same as the
     flow-id specified in IPv6.

   o Cut-through packet forwarding
     Packets are forwarded without any IP processing at the router
     using the datalink level information (e.g.,VPI/VCI).
     Internetworking level information (e.g., destination IP address)
     is mapped to the corresponding datalink-level identifier by using
     the FANP.

   o Hop-by-Hop packet forwarding
     Packets are forwarded using IP level information like conventional
     routers. In ATM, cells are re-assembled into packets at the
     router to analyze the IP header.

   o Default-VC
     Default-VC is used for hop-by-hop packet forwarding. Cells
     received from the Default-VC are reassembled into IP packets.
     Conventional IP processing is performed for these packets. The
     encapsulation over the Default-VC is LLC for routed non-ISO
     protocols defined by RFC1483 [3].

   o Dedicated-VC
     Dedicated-VC is used for the specific IP packet flow identified by
     the flow-ID. When the flow-ID for an incoming VC and an outgoing
     VC are the same at a CSR, it can forward the packets belonging to
     the flow through the cut-through packet forwarding. The
     encapsulation over the Dedicated-VC is LLC for routed non-ISO
     protocols defined by RFC1483 [3].

   o Cut-through trigger
     When a FANP capable node receives a trigger packet, it tries to
     establish Dedicated-VC and to notify the mapping information
     between the Dedicated-VC and the IP packet flow which the received
     trigger packet belongs to. Trigger packets are defined by the
     port-ID of TCP/UDP with the local policy of each FANP capable
     node. In general, they would be the port-ID's of sessions with a
     long life-time and/or with large amount of packets; e.g., http,
     ftp and nntp. Future implementation will include other triggers
     such as an arrival of resource reservation request.

4. Protocol Overview

   Figure 1 shows an operational overview of FANP. In the figure, a
   cut-through packet forwarding path is established from host 1 (H1) to
   host 2 (H2) using two Dedicated-VCs. H1 and H2 are connected to
   Ethernets, and R1, R2 and R3 are routers which can speak FANP. R1
   and R3 have both an ATM interface and an Ethernet interface. R2 has
   two ATM interfaces.

   When R1 receives an IP packet from H1, R1 analyzes the payload of the
   received IP packet whether it is a trigger packet or not. When the
   received packet is a trigger packet, R1 fetches a Dedicated-VC to its
   downstream neighbor(R2) and sends FANP messages. FANP is effective
   between the neighboring nodes only. The same procedure would be
   performed between R2 and R3 independently from the procedure between
   R1 and R2. The flow-ID of the packet flow from H1 to H2 is
   represented as id(H1,H2). Here, id(H1,H2) is the set of the IP
   address of H1 and that of H2.

The Dedicated-VC is released when no packet is transferred on it for
a given period. We do not need to explicitly indicate release of the
Dedicated-VC to the neighbor node, since the state management in FANP
is of soft-state, rather than of hard-state.

```
  +--+ Ethernet +--+   +-----+   +--+   +-----+   +--+ Ethernet +--+
  |H1|----------|R1|---| ATM |---|R2|---| ATM |---|R3|----------|H2|
  +--+          +--+   +-----+   +--+   +-----+   +--+          +--+
     trigger pkt
     |---------> trigger packet
                  |-------------->   trigger packet
                     FANP            |-------------->  trigger pkt
                  <=============>         FANP         |----------->
                                    <=============>

                  |============|
                   Dedicated-VC    |=============|
                                    Dedicated-VC
```
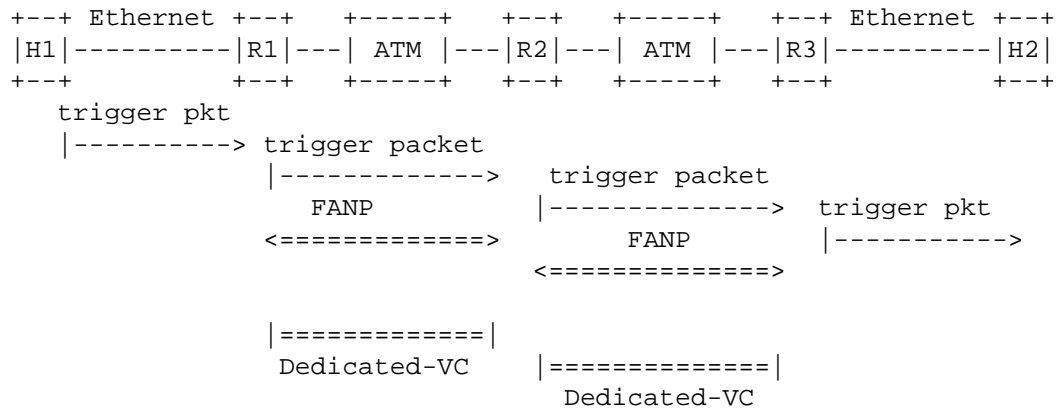
             Figure 1. Trigger packet and FANP initiation

5. Protocol Sequence

   FANP has the following five procedures, that are (1) Dedicated-VC
   selection, (2) VCID negotiation, (3) flow-ID notification, (4)
   Dedicated-VC refresh and (5) Dedicated-VC release. Procedures (2),
   (3) and (4) have nothing to do with the kind of the Dedicated-
   VC;i.e.,SVC,PVC or VP. On the contrary, the procedures (1) and (5)
   with SVC are different from the procedures with PVC and with VP.

   The detailed procedures are described in the following subsections.

5.1 Dedicated-VC Selection Procedure

   A VC is picked up in order to use as a Dedicated-VC. The ways of
   picking up the Dedicated-VC is either of the followings.

   (1) A number of VCs are prepared in advance, and registered into an
       un-used VC list. When a Dedicated-VC is needed, one of them is
       picked up from the un-used VC list.

   (2) A new VC is established through ATM signaling on demand.

   With ATM PVC/VP configuration, a Dedicated-VC is activated by the
   procedure (1).

With ATM SVC configuration, a Dedicated-VC is activated by the
procedure (1) or (2). When the procedure (1) is used, some number of
VCs are prepared in advance through ATM signaling. These VCs are
registered into the un-used VC list. When a Dedicated-VC is needed,
a VC is picked up from the un-used VC list. When the procedure (2)
is used, a Dedicated-VC is established through ATM signaling each
time it is required.

The procedure (1) can decrease a time to activate a Dedicated-VC.
But the necessary VC resource will increase as it need to prepare
additional VCs. Which procedure should be applied to is a matter of
local decision in each node, taking the economical requirement and
the system responsiveness into account.

A Dedicated-VC is used as a uni-directional VC, although it is
generally bi-directional. This means that packets are transferred
only from upstream node to downstream node in the Dedicated-VC. The
packets from downstream node to upstream node are transferred through
the Default-VC or through another Dedicated-VC.

5.2 VCID Negotiation Procedure

After the Dedicated-VC selection procedure, the upstream node
transmits the PROPOSE message to the downstream node through the
Dedicated-VC. The PROPOSE message contains a VCID for the
Dedicated-VC and IP address (target IP address) of downstream node.
When the downstream node accepts the PROPOSE message, it transmits
the PROPOSE ACK message to the upstream node through the Default-VC.
With this procedure, the upstream and the downstream nodes (both
end-points of the Dedicated-VC) can share the same indicator "VCID"
for the Dedicated-VC. When the downstream node can not accept the
proposal from the upstream node with some reason (e.g., policy), the
downstream node sends an ERROR message to the upstream node through
the Default-VC.

The procedure at the downstream node which has received PROPOSE
message is;

  1. if(Target IP address of the PROPOSE message isn't equal to my IP
        address)
     then Goto end.

  2. if(The PROPOSE message should be refused)
     then Send an ERROR(refuse by policy) message. Go to end.

  3. if(VCID Type in the PROPOSE message isn't known)
     then Send an ERROR(unknown VCID Type) message. Go to end.

   4. if(The VCID in the PROPOSE message is the same as the VCID which
      has already been registered for another Dedicated-VC in the node)
      then Delete the registered VCID.
      Release the old Dedicated-VC.

   5. if(A VCID is registered for the Dedicated-VC which has received
      the PROPOSE message)
      then Delete the registered VCID.

   6. Register the mapping between VCID and I/F, VPI, VCI for the
      Dedicated-VC.

   7. if(The mapping is successful)
      then Send a PROPOSE ACK.
      else Send an ERROR(resource unavailable).

   The upstream node retransmits the PROPOSE message when it neither
   receive PROPOSE ACK message nor ERROR message. When the upstream
   node has received neither of the messages even with five
   retransmissions of the PROPOSE message, the Dedicated-VC picked up
   through the Dedicated-VC selection procedure should be released.
   Here, the number of retransmissions (five in this specification)is
   recommended value and can be modified in the future.

   The purpose of the VCID negotiation procedure is not only to share
   the VCID information regarding the Dedicated-VC, but also to confirm
   whether the Dedicated-VC is available and whether the neighbor node
   operates correctly.

   If the VCID negotiation procedure with a neighbor node always fails,
   it is considered that the node may not be FANP-capable node.
   Therefore the upstream node should not try the VCID negotiation
   procedure to that node for a certain time period.

5.3 Flow-ID Notification Procedure

   After the VCID negotiation procedure, the upstream node transmits an
   OFFER message to the downstream node through the Default-VC. The
   OFFER message contains the VCID of the Dedicated-VC, the flow-ID of
   the packet flow transferred through the Dedicated-VC and the refresh
   interval of a READY message.

   When the downstream node receives the OFFER message from the upstream
   node, it transmits the READY message to the upstream node through the
   Default-VC in order to indicate that the OFFER message issued by the
   upstream node is accepted. By the reception of the READY message,
   the upstream node realizes that the downstream node can receive IP
   packets transferred through the Dedicated-VC.

   The upstream node retransmits the OFFER message when it does not
   receive a READY message from the downstream node. When the upstream
   node has not receive a READY message even with five retransmissions,
   the Dedicated-VC should be released. Here, the number of
   retransmissions (i.e., five in this specification) is a recommended
   value and may be modified in the future.

   The node transmits an ERROR message to its neighbor in the following
   cases. When the node receives the ERROR message, the Dedicated-VC
   should be released.

    (a) unknown VCID: The VCID in the message is unknown.
    (b) unknown VCID Type: The VCID Type is unknown.
    (c) unknown flow-ID Type: the flow-ID Type is unknown.

   When the downstream node accepts the OFFER message from the upstream
   node, it must send a READY message to the upstream node within the
   refresh interval offered by the upstream node. If it can not, the
   downstream node sends the ERROR message (this refresh interval is not
   supported) to the upstream node. The downstream node should accept
   the refresh interval larger than 120 seconds. Therefore the
   downstream node shouldn't send the ERROR message (this refresh
   interval is not supported) when the refresh interval in the OFFER
   message is larger than 120 seconds.

   The following describes the procedure of the node which has received
   an OFFER message.

    1. if(unknown version in the OFFER message)
       then Discard the message. Goto end.

    2. if(unknown VCID Type in the OFFER message)
       then Send an ERROR (unknown VCID Type) message. Goto end.

    3. if(VCID in the OFFER message has not been registered)
       then Send an ERROR (unknown VCID) message. Goto end.

    4. if(unknown Flow ID Type in the OFFER message)
       then Send an ERROR (unknown Flow ID Type) message. Goto end.

    5. if(refuse Flow ID in the OFFER message)
       then Send an ERROR (refused by policy) message. Goto end.

    6. if(refuse refresh interval in the OFFER message)
       then Send an ERROR(This refresh interval is not supported)
       message. Goto end.

     7. if(the mapping between Flow ID and VCID already exists and
           Flow ID in the OFFER message is different from the registered
           Flow ID for the corresponding VCID)
        then Do Flow-ID removal procedure. Goto end.

     8. Do the procedure of receiving the OFFER message.

     7. if(successful)
        then Send a READY message.
        else Send an ERROR (resource unavailable) message.

     8. end.

   The procedure of the node which has received a READY message is
   described.

     1. if(unknown version in the READY message)
        then Discard the message. Goto end.

     2. if(unknown VCID Type in the READY message)
        then Send an ERROR (unknown VCID Type) message. Goto end.

     3. if(VCID in the READY message has not been registered)
        then Send an ERROR (unknown VCID) message. Goto end.

     4. if(unknown Flow ID Type in the READY message)
        then Send an ERROR (unknown Flow ID Type) message. Goto end.

     5. if((the mapping between Flow ID and VCID doesn't exist)||
           (the mapping between Flow ID and VCID already exists and
            Flow ID in the READY message is different from registered Flow
            ID for the corresponding VCID))
        then Send an ERROR (unknown VCID) message. Goto end.

     6. Do the procedure of receiving the READY message.

     7. end.

5.4 Flow ID Refresh Procedure

   While the downstream node receives IP packets through the Dedicated-
   VC, it should periodically (with a refresh interval) send the READY
   message to the upstream node. When the downstream node does not
   receive any IP packet during the refresh interval, it does not send
   the READY message to the upstream node.

While the upstream node continues to receive READY messages, it
realizes that it can transmit the IP packets through the Dedicated-
VC. When it does not receive a READY message at all for a
predetermined period (dead interval), it removes the mapping between
the Flow IP and VCID. The dead interval is defined below.

When the upstream node falls into failure without the Flow ID removal
procedure for a Dedicated-VC, its mapping must be removed by the
downstream node. The downstream node removes the mapping between the
Flow ID and VCID for the Dedicated-VC when it does not receive any IP
packet for a "removal period" (=refresh interval times m).

The refresh interval, the dead interval and the removal period should
satisfy the following equation.

  refresh interval < dead interval < removal period (=refresh
  interval times m)

  The recommended values are:
      refresh interval = 2 minutes
      dead interval   = 6 minutes (=refresh interval x 3)
      removal period = 20 minutes (=refresh interval x 10)

5.5 Flow ID Removal Procedure

When the upstream node realizes that the Dedicated-VC is not used, it
performs a Flow ID removal procedure.

The Flow ID removal procedure differs between the case of PVC/VP
configuration and the case of SVC configuration.

With the PVC/VP configuration, the upstream node issues a REMOVE
message to the downstream node, and the downstream node sends back a
REMOVE ACK message to the upstream node. The upstream node
retransmits REMOVE messages when it does not receive a REMOVE ACK
message. The upstream node assumes that the downstream node is in
failure state when it dose not receive any REMOVE ACK message from
the downstream node even with five REMOVE message retransmissions.

With SVC configuration, two procedures are possible. One is that the
mapping between the Flow ID and the VCID is removed without the
release of the ATM connection, which is the same procedure as the
PVC/VP configuration. The other procedure is that the mapping
between the Flow ID and the VCID is removed by releasing the VC
through ATM signaling. The former procedure can promptly create and
delete the mapping between Flow ID and VCID, since the ATM signaling
does not have to be performed each time. However, an un-used ATM
connections have to be maintained by the node. Which procedure is
applied to is a matter of each CSR's local decision, taking the VC
resource cost and responsiveness into account.

The downstream node may want to remove the mapping between the Flow
ID and the VCID. When the upstream node receives the REMOVE message,
it sends a REMOVE ACK message to the downstream node.

```
            +--+                                  +--+
            |R1|----------------------------------|R2|
            +--+                                  +--+
              |              PROPOSE               |
              |==================================>|
    VCID      |          [VCID, target IP]         |
  negotiation |            PROPOSE ACK             |
              |<==================================|
              |               [VCID]               |
              |                                    |
              |               OFFER                |
              |==================================>|
   Flow-ID    |          [VCID, flow-ID]           |
  notification|              READY                 |
              |<==================================|
              |          [VCID, flow-ID]           |
              |                                    |
                  :           :            :
                  :           :            :
              |              READY                 |
              |<==================================|
  Dedicated-VC|          [VCID, flow-ID]           |
   refresh    |              READY                 |
              |<==================================|
              |          [VCID, flow-ID]           |
```
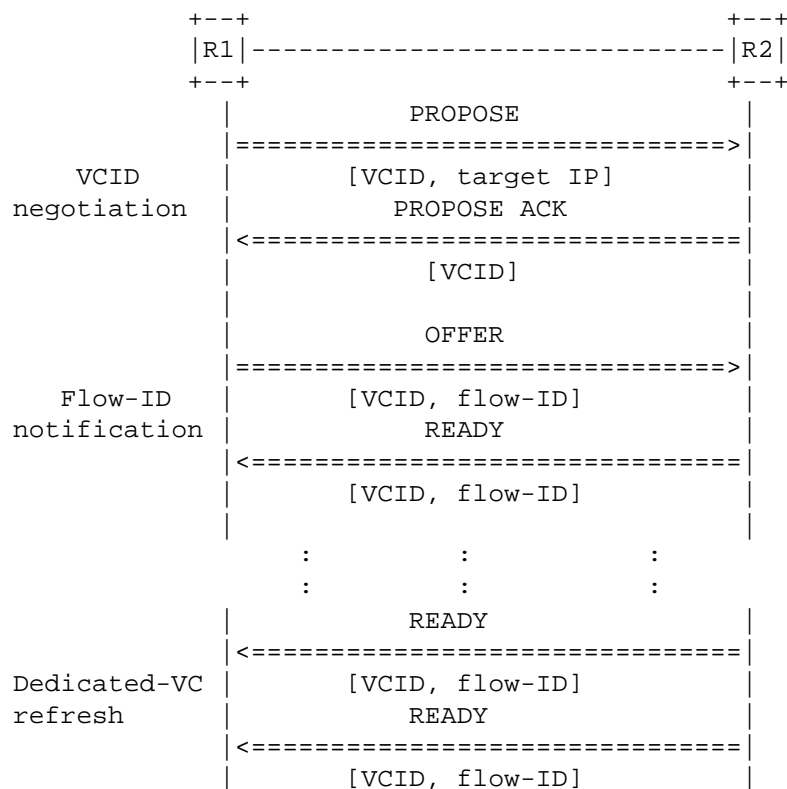
           Figure 2. Flow ID notification and refresh procedure

```
        +--+                                          +--+
        |R1|------------------------------|R2|
        +--+                                          +--+
         |                                             |
         |               REMOVE                        |
         |===============================>|
         |               [VCID]                        |
         |                                             |
         |             REMOVE ACK                      |
         |<===============================|
         |               [VCID]                        |
```
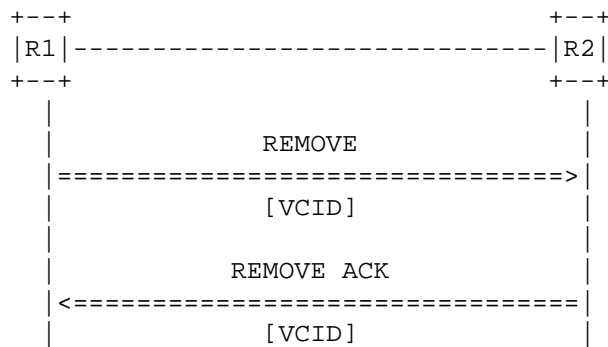
           (a) Flow ID removal (independent of ATM signaling)


```
        +--+                                          +--+
        |R1|------------------------------|R2|
        +--+                                          +--+
         |              ATM signaling                  |
         |                (release)                    |
         |<===============================>|
         |                                             |
```
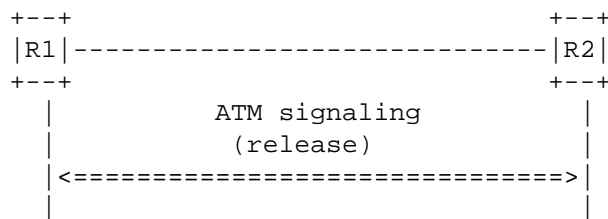
           (b) Flow ID removal through ATM signaling

           Figure 3. Flow ID removal procedure

6. Message Format

   FANP control procedure includes seven messages described from 6.2 to
   6.8. Among them, a PROPOSE message used for VCID negotiation
   procedure uses an extended ATM ARP message format defined in RFC1577
   [2]. The other messages are encapsulated into IP packets.

   The destination IP address in the IP packet header signifies the
   neighbor node's IP address and the source IP address signifies
   sender's IP address. Currently, the protocol ID for these messages
   is 110(decimal). This protocol ID must be registered by IANA.

   The reserved field in the following packet format must be zero.

6.1 Field Format

6.1.1 VCID field

   VCID type value decides VCID field format. Currently, only type "1"
   is defined. The VCID field format of VCID type 1 is shown below.

```
     0                   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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                    ESI of upstream node                      |
    +                           +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                           |                                  |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+                                  +
    |                             ID                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
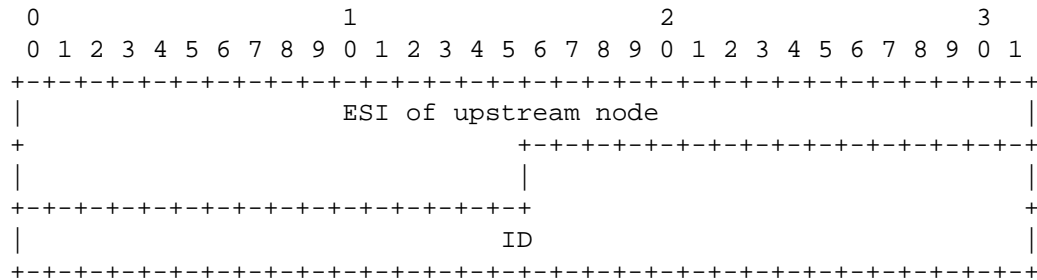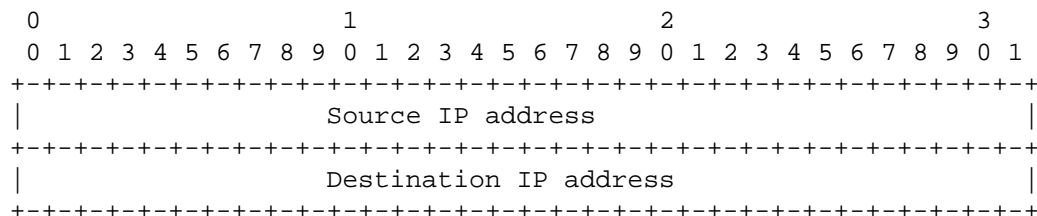
       ESI field: ESI of upstream node
       ID   : upstream node decides unique identifier.

6.1.2 Flow ID field

   Flow ID type value decides flow-ID field format. Currently, flow-ID
   type "0" and "1" are defined. The flow ID type value "0" signifies
   that the flow ID field is null. When flow ID type value is "1", the
   format shown below is used.

```
     0                   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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                      Source IP address                       |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                    Destination IP address                    |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

       Source IP address   : source IP address of flow
       Destination IP address : destination IP address of flow

6.2 PROPOSE message

   PROPOSE message uses the extended ATM-ARP message format [2] to which
   the VCID type and the VCID field are added. Type & Length fields are
   set to zero, because the messages don't need sender/target ATM
   address. This message is transferred from the upstream node to the
   downstream node through the Dedicated-VC.

   PROPOSE message is transferred from the upstream node to the
   downstream node through the Dedicated-VC.
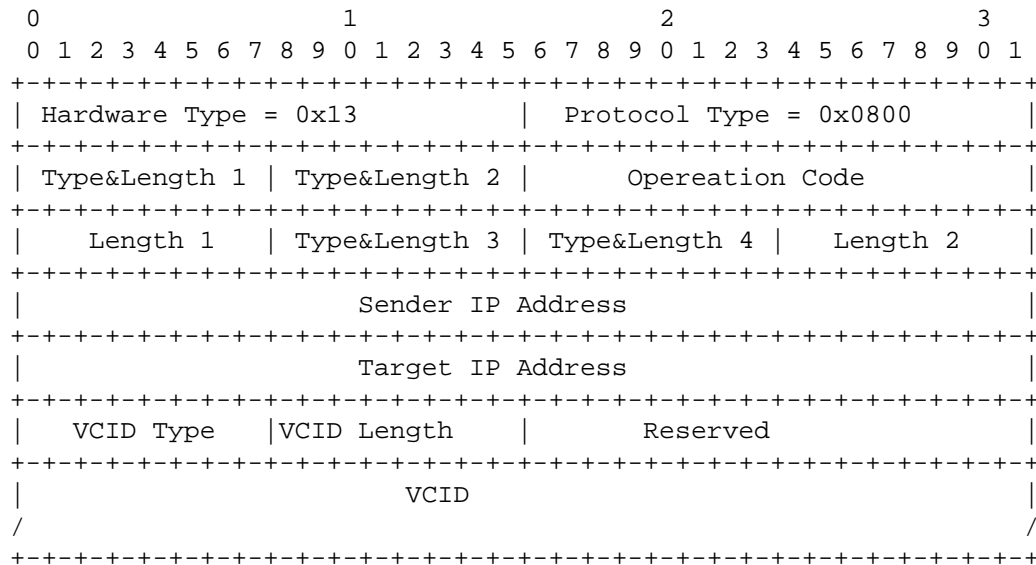
```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Hardware Type = 0x13          |  Protocol Type = 0x0800       |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Type&Length 1 | Type&Length 2 |      Opereation Code          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |    Length 1   | Type&Length 3 | Type&Length 4 |    Length 2   |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                      Sender IP Address                        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                      Target IP Address                        |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |   VCID Type   |VCID Length    |          Reserved             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                          VCID                                 |
    /                                                               /
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+


    Type&Length 1 ; Type & Length of sender ATM number = 0
    Type&Length 2 ; Type & Length of sender ATM subnumber = 0
    Type&Length 3 ; Type & Length of sender ATM number = 0
    Type&Length 4 ; Type & Length of sender ATM subnumber =0
    Length 1      ; Source IP address length
    Length 2      ; Target IP address length


    Operation code
            0x10 = PROPOSE

    VCID Type:   Currently , VCID Type = 1 is defined.
    VCID Length: Length of VCID field
    VCID :       VCID described previous
```
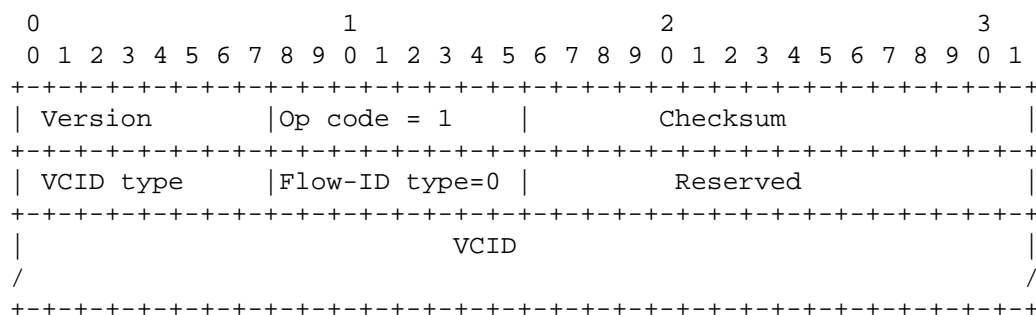
6.3 PROPOSE ACK

   PROPOSE ACK messages is transferred through the Default-VC.

```
     0                   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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Version       |Op code = 1    |          Checksum             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | VCID type     |Flow-ID type=0 |          Reserved             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                          VCID                                 |
    /                                                               /
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Version
    This field indicates the version   number of FANP.   Currently,
    Version = 1

Operation Code

    This field indicates the operation code   of the message. There
    are five operation codes, below.

    operation code = 1 : PROPOSE ACK message
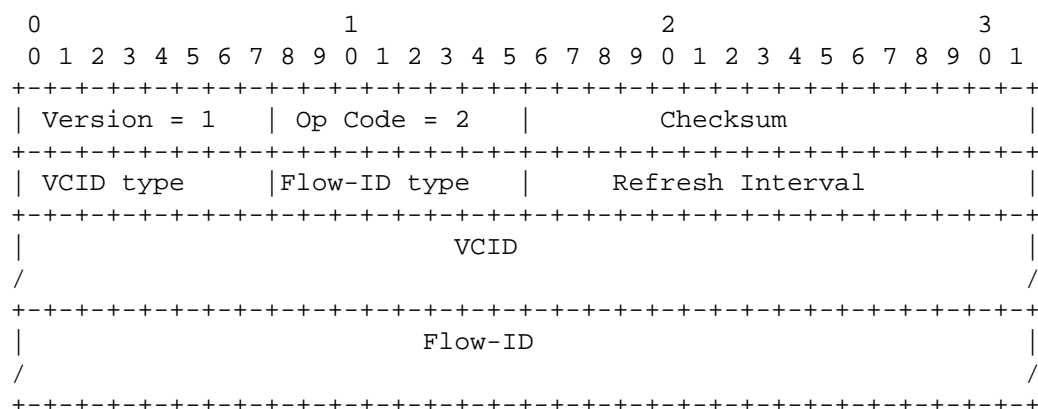
Checksum
    This field is the 16 bits checksum for whole body of FANP message.
    The checksum algorithm is same as the IP header.

VCID Type
    This field indicates the VCID type. Currently, only "1" is
    defined.

6.4 OFFER message

  OFFER message is transferred from an upstream node to a downstream
  node. The following is the message format.

```
  0                   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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | Version = 1   | Op Code = 2   |         Checksum             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | VCID type     |Flow-ID type   |      Refresh Interval        |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                          VCID                                 |
 /                                                              /
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                         Flow-ID                               |
 /                                                              /
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Refresh Interval
    This field indicates the interval of refresh timer. The refresh
    interval is represented by second in integer. This field is
    used only in OFFER message. Recommended value is 120 (second).

6.5 READY message

   READY message is transfered from a downstream node to an upstream
   node. This message is transferred when the downstream node receives
   OFFER message. And this message is transferred periodically in each
   refresh interval. The following is the message format.

```
     0                   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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Version = 1   | Op Code = 3   |          Checksum             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | VCID type     |Flow-ID type   |          Reserved             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                             VCID                              |
    /                                                               /
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                           Flow-ID                             |
    /                                                               /
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

6.6 ERROR message

   ERROR message is transfered from a downstream node to an upstream
   node or from an upstream node to a downstream node. This message is
   transferred when some of the fields in the receive message is unknown
   or refused. When the receive message is the ERROR message, ERROR
   message isn't sent. VCID type ,VCID, Flow ID Type and Flow ID field
   in the ERROR message are filled with the same field in the receive
   message.

   The following is the message format.

```
     0                   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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | Version = 1   | Op Code = 4   |          Checksum             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | VCID type     |Flow-ID type   |        Error code             |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                             VCID                              |
    /                                                               /
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                           Flow-ID                             |
    /                                                               /
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
   Error Code = 1 : unknown VCID type
             = 2 : unknown Flow-ID type
             = 3 : unknown VCID
             = 4 : resource is unavailable
             = 5 : unavailable refresh interval is offered
             = 6 : refuse by policy
```

6.7 REMOVE message

   REMOVE message is transfered from a downstream node to an upstream
   node or vice versa. This message is transfered to remove the
   mapping relationship between the flow ID and and the VCID. The node
   which receives REMOVE message must send REMOVE ACK message, even when
   VCID in the receive message isn't known .

   The following is the message format.

```
    0                   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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Version = 1   | Op Code = 5   |            Checksum           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | VCID type     |Flow-ID type   |        Reserved               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                             VCID                              |
   /                                                              /
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

6.8 REMOVE ACK message

   REMOVE ACK message is transfered from a downstream node to an
   upstream node or from an upstream node to a downstream node. The
   following is the message format.

```
    0                   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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Version = 1   | Op Code = 6   |            Checksum           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | VCID type     |Flow-ID type   |        Reserved               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                             VCID                              |
   /                                                              /
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

7. Security Considerations

    Security issues are not discussed in this memo.

8. References

    [1] Katsube, Y., Nagami, K., and H. Esaki, "Router Architecture
        Extensions for ATM; overview", Work in Progress.

    [2] Laubach, M., "Classical IP and ARP over ATM", RFC 1577,
        October 1993.

    [3] Heinanen, J., "Multiprotocol Encapsulation over ATM Adaptation
        Layer 5", RFC 1483, July 1993.

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