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Ipsilon Flow Management Protocol Specification for IPv4
Version 1.0

Status of this Memo

IESG Note:

This memo documents a private protocol for IPv4-based flows. This protocol is NOT the product of an IETF working group nor is it a standards track document. It has not necessarily benefited from the widespread and in depth community review that standards track documents receive.

Abstract

The Ipsilon Flow Management Protocol (IFMP), is a protocol for allowing a node to instruct an adjacent node to attach a layer 2 label to a specified IP flow. The label allows more efficient access to cached routing information for that flow. The label can also enable a node to switch further packets belonging to the specified flow at layer 2 rather than forwarding them at layer 3.

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1. Introduction

The Ipsilon Flow Management Protocol (IFMP), is a protocol for instructing an adjacent node to attach a layer 2 label to a specified IP flow. The label allows more efficient access to cached routing information for that flow and it allows the flow to be switched rather than routed in certain cases.

If a network node's upstream and downstream links both redirect a flow at the node, then the node can switch the flow at the data link layer rather than forwarding it at the network layer. The label space is managed at the downstream end of each link and redirection messages are sent upstream to associate a particular flow with a given label. Each direction of transmission on a link is treated separately.

If the flow is not refreshed by the time the lifetime field in the redirect message expires, then the association between the flow and the label is discarded. A flow is refreshed by sending a redirect message, identical to the original, before the lifetime expires.

Several flow types may be specified. Each flow type specifies the set of fields from the packet header that are used to identify a flow. There must be an ordering amongst the different flow types such that a most specific match operation may be performed.

A particular flow is specified by a flow identifier. The flow identifier for that flow gives the contents of the set of fields from the packet header as defined for the flow type to which it belongs.

This document specifies the IFMP protocol for IPv4 on a point-to-point link. The definition of labels, and the encapsulation of flows, are specified in a separate document for each specific data link technology. The specification for ATM data links is given in [ENCAP].

2. Flow Types

A flow is a sequence of packets that are sent from a particular source to a particular (unicast or multicast) destination and that are related in terms of their routing and any logical handling policy they may require.

A flow is identified by its flow identifier.

Several different flow types can be defined. The particular set of fields from the packet header used to identify a flow constitutes the flow type. The values of these fields, for a particular flow, constitutes the flow identifier for that flow. The values of these fields must be invariant in all packets belonging to the same flow at any point in the network.

Flow types are sub- or super-sets of each other such that there is a clear hierarchy of flow types. This permits a most specific match operation to be performed. (If additional flow types are defined in the future that are not fully ordered then the required behavior will be defined.) Each flow type also specifies an encapsulation that is to be used after a flow of this type is redirected. The encapsulations for each flow type are specified in a separate document for each specific data link technology. The encapsulations for flows over ATM data links are given in [ENCAP].

Three flow types are defined in this version of the protocol:

Flow Type 0

Flow Type 0 is used to change the encapsulation of IPv4 packets from the default encapsulation.

For Flow Type 0: Flow Type = 0 and Flow ID Length = 0.

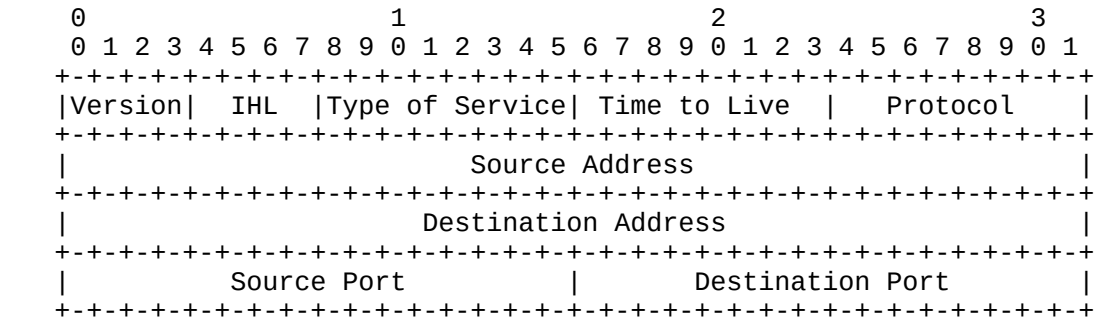
The Flow Identifier for Flow Type 0 is null (zero length).

Flow Type 1

Flow Type 1 is designed for protocols such as UDP and TCP in which the first four octets after the IPv4 header specify a Source Port number and a Destination Port number.

For Flow Type 1, Flow Type = 1 and Flow ID Length = 4 (32 bit words).

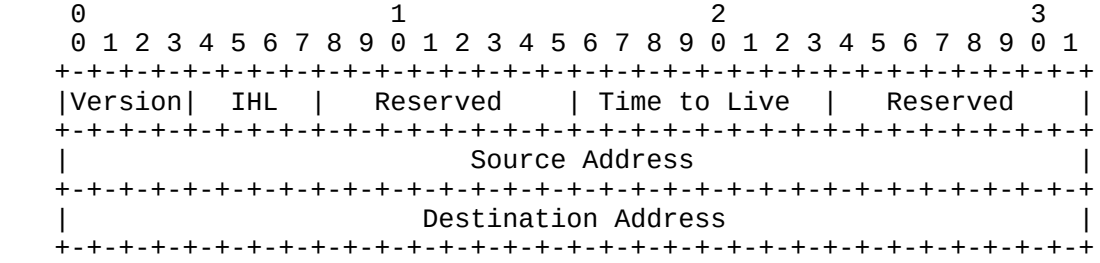
The format of the Flow Identifier for Flow Type 1 is:



Flow Type 2

For Flow Type 2, Flow Type = 2 and Flow ID Length = 3 (32 bit words).

The format of the Flow Identifier for Flow Type 2 is:



The Reserved fields are unused and should be set to zero by the sender and ignored by the receiver.

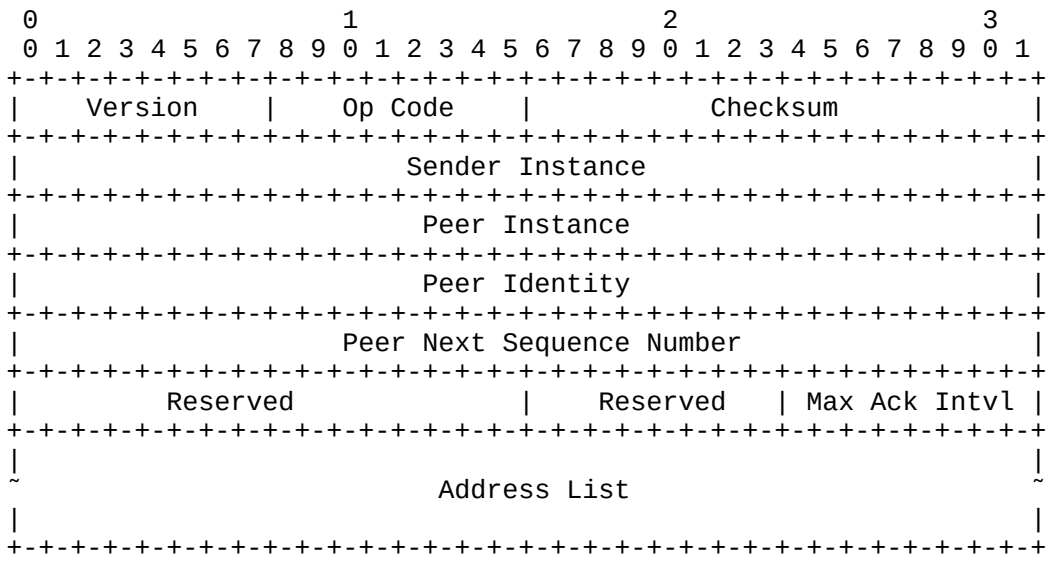
3. IFMP Adjacency Protocol

The IFMP Adjacency Protocol allows a host or router to discover the identity of a peer at the other end of a link. It is also used to synchronize state across the link, to detect when the peer at the other end of the link changes, and to exchange a list of IP addresses assigned to the link.

3.1 Packet Format

All IFMP messages belonging to the Adjacency Protocol must be encapsulated within an IPv4 packet and must be sent to the IP limited broadcast address (255.255.255.255). The Protocol field in the IP header must contain the value 101 (decimal) indicating that the IP packet contains an IFMP message. The Time to Live (TTL) field in the IP header must be set to 1.

All IFMP messages belonging to the adjacency protocol have the following structure:



Version

The IFMP protocol version number. The current Version = 1.

Op Code

Specifies the function of the message. Four Op Codes are defined for the IFMP Adjacency Protocol:

SYN: Op Code = 0
SYNACK: Op Code = 1
RSTACK: Op Code = 2
ACK: Op Code = 3

Checksum

The 16-bit one's complement of the one's complement sum of a pseudo header of information from the IP header and the IFMP message itself. The pseudo header, conceptually prefixed to the IFMP message, contains the Source Address, the Destination Address, and the Protocol fields from the IPv4 header, and the total length of the IFMP message starting with the Version field (this is equivalent to the value of the Total Length field from the IPv4 header minus the length of the IPv4 header itself).

Sender Instance
: For the SYN, SYNACK, and ACK messages, is the sender's instance number for the link. The receiver uses this to detect when the link comes back up after going down or when the identity of the peer at the other end of the link changes. The instance number is a 32 bit number that is guaranteed to be unique within the recent past and to change when the link or node comes back up after going down. It is used in a similar manner to the initial sequence number (ISN) in TCP [RFC 793]. Zero is not a valid instance number. For the RSTACK message the Sender Instance field is set to the value of the Peer Instance field from the incoming message that caused an RSTACK message to be generated.

Peer Instance
: For the SYN, SYNACK, and ACK messages, is what the sender believes is the peer's current instance number for the link. If the sender of the message does not know the peer's current instance number for the link, the sender must set this field to zero. For the RSTACK message the Peer Instance field is set to the value of the Sender Instance field from the incoming message that caused an RSTACK message to be generated.

Peer Identity
: For the SYN, SYNACK, and ACK messages, is the IP address of the peer that the sender of the message believes is at the other end of the link. The Peer Identity is taken from the Source IP Address of the IP header of a SYN or a SYNACK message. If the sender of the message does not know the IP address of the peer at the other end of the link, the sender must set set this field to zero. For the RSTACK message, the Peer Identity field is set to the value of the Source Address field from the IP header of the incoming message that caused an RSTACK message to be generated.

Peer Next Sequence Number
: Gives the value of the peer's Sequence Number that the sender of the IFMP Adjacency Protocol message expects to arrive in the next IFMP Redirection Protocol message. If a node is in the ESTAB state, and the value of the Peer Next Sequence Number in an incoming ACK message is greater than the value of the Sequence Number plus one, from the last IFMP Redirection Protocol message transmitted out of the port on which the incoming ACK message was received, the link should be reset. The procedure to reset the link is defined in section 3.2.

Max Ack Intvl
: Maximum Acknowledgement Interval is the maximum amount of time the sender of the message will wait until transmitting an ACK message.

Address List
: A list of one or more IP addresses that are assigned to the link by the sender of the message. The list must have at least one entry that is identical to the Source Address in the IP header. The contents of this list are not used by the IFMP protocol but can be made available to the routing protocol.

3.2 Procedure

The IFMP Adjacency Protocol is described by the rules and state tables given in this section.

The rules and state tables use the following operations:

- The "Update Peer Verifier" operation is defined as storing the Sender Instance and the Source IP Address from a SYN or SYNACK message received from the peer on a particular port.

- The procedure "Reset the link" is defined as:

  1. Generate a new instance number for the link
  2. Delete the peer verifier (set the stored values of Sender Instance and Source IP Address of the peer to zero)
  3. Set Sequence Number and Peer Next Sequence Number to zero
  4. Send a SYN message
  5. Enter the SYNSENT state

- The state tables use the following Boolean terms and operators:

  A
  : The Sender Instance in the incoming message matches the value stored from a previous message by the "Update Peer Verifier" operation for the port on which the incoming message is received.

  B
  : The Sender Instance and the Source IP Address in the incoming message matches the value stored from a previous message by the "Update Peer Verifier" operation for the port on which the incoming message is received.

C The Peer Instance and Peer Identity in the incoming message matches the value of the Sender Instance and the Source IP Address currently in use for all SYN, SYNACK, and ACK messages transmitted out of the port on which the incoming message was received.

"&&" Represents the logical AND operation

"||" Represents the logical OR operation

"!" Represents the logical negation (NOT) operation.

- A timer is required for the periodic generation of SYN, SYNACK, and ACK messages. The period of the timer is unspecified but a value of one second is suggested.

  There are two independent events: the timer expires, and a packet arrives. The processing rules for these events are:

```
Timer Expires:   Reset Timer
                 If state = SYNSENT Send SYN
                 If state = SYNRCVD Send SYNACK
                 If state = ESTAB   Send ACK

Packet Arrives:  If incoming message is an RSTACK
                    If A && C && !SYNSENT
                       Reset the link
                    Else Discard the message
                 Else the following State Tables.
```

- State synchronization across a link is considered to be achieved when a node reaches the ESTAB state.

State Tables

State: SYNSENT

Condition	Action	New State
SYNACK && C	Update Peer Verifier; Send ACK	ESTAB
SYNACK && !C	Send RSTACK	SYNSENT
SYN	Update Peer Verifier; Send SYNACK	SYNRCVD
ACK	Send RSTACK	SYNSENT

State: SYNRCVD

Condition	Action	New State
SYNACK && C	Update Peer Verifier; Send ACK	ESTAB
SYNACK && !C	Send RSTACK	SYNRCVD
SYN	Update Peer Verifier; Send SYNACK	SYNRCVD
ACK && B && C	Send ACK	ESTAB
ACK && !(B && C)	Send RSTACK	SYNRCVD

State: ESTAB

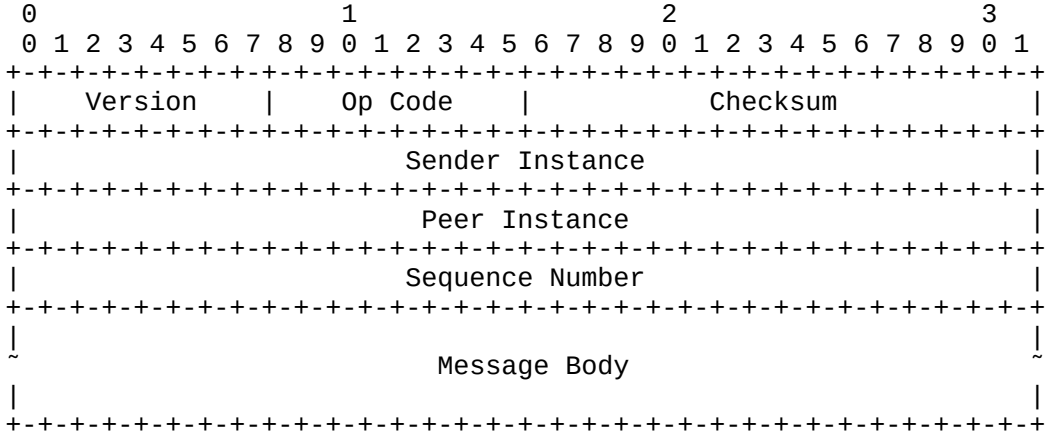
Condition	Action	New State
SYN || SYNACK	Send ACK (note 1)	ESTAB
ACK && B && C	Send ACK (note 1)	ESTAB
ACK && !(B && C)	Send RSTACK	ESTAB

Note 1: No more than one ACK should be sent within any time period of length defined by the timer.

4. IFMP Redirection Protocol

A sender encapsulates within an IPv4 packet all IFMP messages belonging to the Redirection Protocol. The sender sends these messages to the unicast IP address of the peer at the other end of the link. The IP address of the peer is obtained from the adjacency protocol. The Protocol field in the IP header must contain the value 101 (decimal) indicating that the IP packet contains an IFMP message. The Time to Live (TTL) field in the IP header must be set to 1.

All IFMP Redirection Protocol messages have the following structure:



Version
: The IFMP protocol version number, currently Version = 1.

Op Code
: This field gives the message type. Five message types are currently defined for the IFMP Redirection Protocol:

REDIRECT:	Op Code = 4
RECLAIM:	Op Code = 5
RECLAIM ACK:	Op Code = 6
LABEL RANGE:	Op Code = 7
ERROR:	Op Code = 8

Checksum
: The 16-bit one’s complement of the one’s complement sum of a pseudo header of information from the IP header, and the IFMP message itself. The pseudo header, conceptually prefixed to the IFMP message, contains the Source Address, the Destination Address, and the Protocol fields from the

IPv4 header, and the total length of the IFMP message starting with the version field (this is equivalent to the value of the Total Length field from the IPv4 header minus the length of the IPv4 header itself).

Sender Instance
: The sender's instance number for the link from the IFMP Adjacency Protocol.

Peer Instance
: What the sender believes is the peer's current instance number for the link from the IFMP Adjacency protocol.

Sequence Number
: The sender must increment by one, modulo 2**32, for every IFMP Redirection Protocol message sent across a link. It allows the receiver to process IFMP Redirection Protocol messages in order. The Sequence Number is set to zero when a node resets the link.

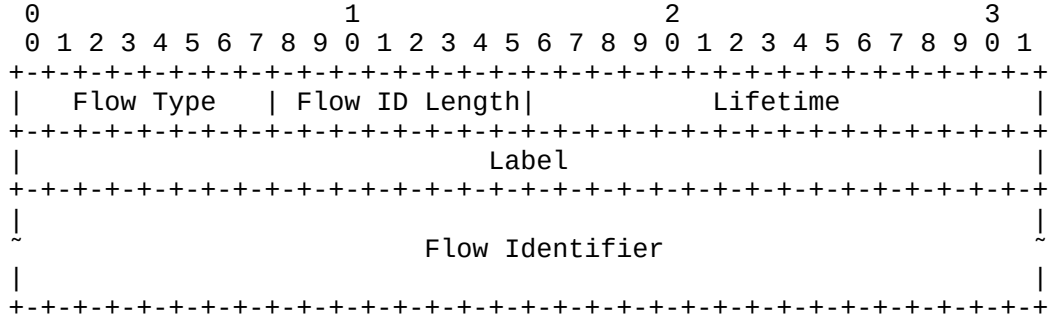
Message Body
: Contains a list of one or more IFMP Redirection Protocol message elements. All of the message elements in the list have the same message type because the Op Code field applies to the entire IFMP message. The number of message elements included in a single packet must not cause the total size of the IFMP message to exceed the MTU size of the underlying data link. Only a single message element is permitted in a Label Range message or in an Error message.

No IFMP Redirection Protocol messages can be sent across a link until the IFMP Adjacency Protocol has achieved state synchronization across that link. All IFMP Redirection Protocol messages received on a link that does not currently have state synchronization must be discarded. For every received IFMP Redirection Protocol message the receiver must check the Source IP Address from the IP header, the Sender Instance, and the Peer Instance. The incoming message must be discarded if the Sender Instance and the Source IP Address fields do not match the values stored by the "Update Peer Verifier" operation of the IFMP Adjacency Protocol for the port on which the message is received. The incoming message must also be discarded if the Peer Instance field does not match the current value for the Sender Instance of the IFMP Adjacency Protocol.

4.1 Redirect Message

The Redirect Message element is used to instruct an adjacent node to attach one or more given labels to packets belonging to one or more specified flows each for a specified period of time. The Redirect message is not acknowledged.

Each Redirect message element has the following structure:



Flow Type
: Specifies the Flow Type of the flow identifier contained in the Flow Identifier field.

Flow ID Length
: Specifies the length of the Flow Identifier field in integer multiples of 32 bit words.

Lifetime field
: Specifies the length of time, in seconds, for which this redirection is valid. The association of flow identifier and label should be discarded at a time no greater than that specified by the Lifetime field. A value of zero is not valid.

Label field
: Contains a 32 bit label. The format of the label is dependent upon the type of physical link across which the Redirect message is sent. (The format of the label for ATM data links is specified in [ENCAP].)

Flow Identifier
: Identifies the flow with which the specified label should be associated. The length of the Flow Identifier field must be an integer multiple of 32 bit words to preserve 32 bit alignment.

A node can send an IFMP message containing one or more Redirect message elements across a link to its upstream neighbor. Each Redirect message element requests that the upstream neighbor associate a given link-level label to packets belonging to a specified flow for up to a specified period of time. A node receiving an IFMP message that contains one or more Redirect message elements from an adjacent downstream neighbor can choose to ignore any or all of the Redirect message elements. Neither the IFMP message nor any of the Redirect message elements are acknowledged. If the node chooses to accept a particular Redirect message element and to redirect the specified flow, it should attach the label specified in the Redirect message element to all further packets sent on that flow until it chooses to do so no longer, or until the specified lifetime expires. While the flow remains redirected, the encapsulation specified by the definition of the Flow Type given in the Redirect message element must be used for all packets belonging to that flow. If the label in a Redirect message element is outside the range that can be handled across the relevant link, a Label Range message can be returned to the sender. The Label Range message informs the sender of the Redirect message of the range of labels that can be sent across the link.

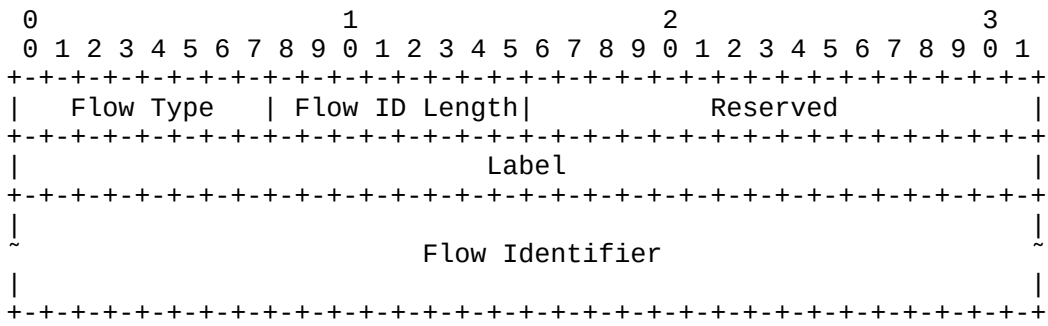
If a Redirect message element is received specifying a flow that is already redirected, the Label field in the received Redirect message element must be checked against the label stored for the redirected flow. If they agree, the lifetime of the redirected flow is reset to that contained in the Redirect message element. If they disagree, the Redirect message element is ignored, and the flow returned to the default state. There is a minimum time between Redirect message elements specifying the same flow. The default value is one second.

If a receiving node detects an error in any of the fields of a Redirect message element, the node must discard that message element without affecting any other Redirect message elements in the same IFMP message. The receiver should return an error message to the sender only in the case that the receiver does not understand the version of the IFMP protocol in the received IFMP message or does not understand a Flow Type in any of the Redirect message elements. An Error Message should be returned for each Flow Type that is not understood.

4.2 Reclaim Message

The Reclaim message element is used by a node to instruct an adjacent upstream node to unbind one or more flows from the labels to which they are currently bound, and to release the labels.

Each Reclaim message element has the following structure:



Flow Type
: Specifies the Flow Type of the Flow Identifier contained in the Flow ID field.

Flow ID Length
: Specifies the length of the Flow Identifier field in integer multiples of 32 bit words.

Reserved
: Field is unused and should be set to zero by the sender and ignored by the receiver.

Label
: Field contains the label to be released.

Flow Identifier
: Field contains the flow identifier to be unbound.

A node can send a Reclaim message element to instruct an adjacent upstream node to unbind a flow from the label to which it is currently bound, return the flow to the default forwarding state, and release the label. Each Reclaim message element applies to a single flow and a single label. When the receiver has completed the operation, it must issue a Reclaim Ack message element. Reclaim Ack message elements can be grouped together, in any order, into one or more IFMP Reclaim Ack messages and returned to the sender as an acknowledgment that the operation is complete.

If a Reclaim message element is received indicating an unknown flow, a Reclaim Ack message element must be returned containing the same Label and Flow Identifier fields from the Reclaim message.

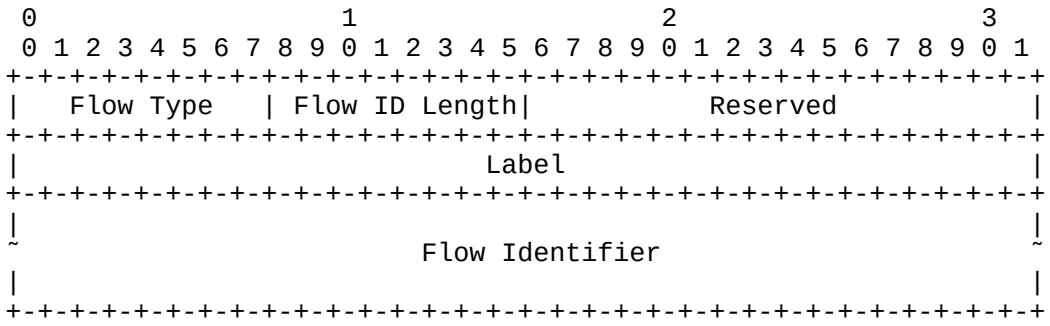
If a Reclaim message element is received indicating a known flow, but with a Label that is not currently bound to that flow, the flow must be unbound and returned to the default forwarding state, and a Reclaim Ack message sent containing the actual label to which the flow was previously bound.

If the receiver detects an error in any of the fields of a Reclaim message element, the receiver must discard that message element, without affecting any other Reclaim message elements in the same message. The receiver must return an error message to the sender only in the case that the receiver does not understand the version of the IFMP protocol in the received message or does not understand a Flow Type in one of the Reclaim message elements.

4.3 Reclaim Ack Message

The Reclaim Ack message element is used by a receiving node to acknowledge the successful release of one or more reclaimed labels.

Each Reclaim Ack message element has the following structure:



Flow Type
: Specifies the Flow Type of the Flow Identifier contained in the Flow Identifier field.

Flow ID Length
: Specifies the length of the Flow Identifier field in integer multiples of 32 bit words.

Reserved
: Field is unused and should be set to zero by the sender and ignored by the receiver.

Label
: Field contains the label released from the flow specified by the Flow Identifier.

Flow Identifier
: Field contains the Flow Identifier from the Reclaim message element that requested the release of the label specified in the Label field.

A Reclaim Ack message element must be sent in response to each Reclaim message element received. It is sent to indicate that the requested flow is now unbound and that the label is now free. If possible, each Reclaim Ack message element should not be sent until all data queued for transmission on the link, using the label specified for release, has been sent.

If a Reclaim Ack message element is received specifying a flow for which no Reclaim message element was issued, that Reclaim Ack message element must be ignored, but no other Reclaim Ack message elements in the same message must be affected.

If a Reclaim Ack message element is received specifying a different label from the one sent in the original Reclaim message element for that flow, the Reclaim Ack message element should be handled as if the reclaim operation were successful.

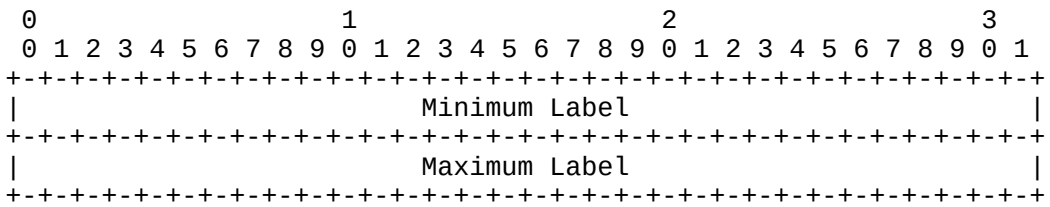
If an error is detected in any of the fields of a Reclaim Ack message element, that message element must be discarded, but no other Reclaim Ack message elements in the same message must be affected.

The receiver should return an Error message to the sender only in the case that the receiver does not understand the version of the IFMP protocol in the received message or does not understand a Flow Type in one of the Reclaim Ack message elements.

4.4 Label Range Message

The Label Range message element is sent in response to a Redirect message if the label requested in one or more of the Redirect message elements is outside the range that the receiver of the Redirect message can handle. The Label Range message informs the sender of the Redirect message of the label range that can be handled on the relevant link.

Only a single Label Range message element is permitted in a Label Range message. The Label Range message element has the following structure:



Minimum Label
The minimum value of label that can be specified in an IFMP Redirection Protocol message across this link.

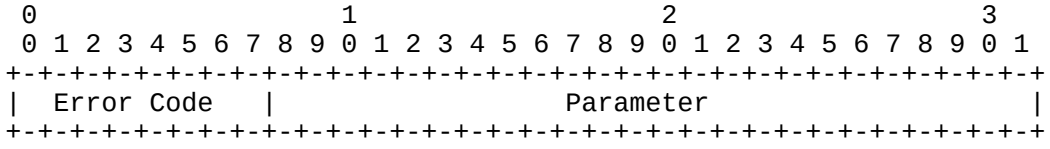
Maximum Label
The maximum value of label that can be specified in an IFMP Redirection Protocol message across this link.

All values of label within the range Minimum Label to Maximum Label inclusive may be specified in an IFMP Redirection Protocol message across the link.

4.5 Error Message

An Error message can be sent by a node in response to any IFMP Redirection Protocol message.

Only a single Error message element is permitted in an Error message. The Error message element has the following structure:



Error Code
Specifies which an error has occurred.

Each Error message can specify a single Parameter.

Two Error message elements are specified:

Bad Version:

Error Code = 1. The sender of the Error message cannot process the version of the IFMP protocol of the message that caused the error. This message must only be sent if the version of the message that caused the error is greater than the most recent version that the sender of the Error message can process. The parameter field of this Error message gives the most recent version of the IFMP protocol that the sender can process, right justified, with the unused most significant bits of the Parameter field set to zero.

Bad Flow Type:

Error Code = 2. The sender of the Error message does not understand a Flow Type that was received in the message that caused the error. The Flow Type that caused the error is given in the parameter field, right justified, with the unused most significant bits of the Parameter field set to zero.

REFERENCES

[ENCAP] Newman, P., et. al., "Transmission of Flow Labelled IPv4 on ATM Data Links Ipsilon Version 1.0," Ipsilon Networks, RFC 1954, May 1996.

[RFC793] Postel, J., "Transmission Control Protocol," STD 7, RFC 793, September 1981.

SECURITY CONSIDERATIONS

Security issues are not discussed in this memo.

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