Network Working Group
Internet Draft
Intended status: Proposed Standard

Expires: August, 2009

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February 5, 2009

# BFD for Multipoint Networks
## draft-katz-ward-bfd-multipoint-02.txt

Abstract

This document describes extensions to the Bidirectional Forwarding Detection (BFD) protocol for its use in multipoint and multicast networks. Comments on this draft should be directed to rtg-bfd@ietf.org.

Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119 [KEYWORDS].

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## 1. Introduction

The Bidirectional Forwarding Detection protocol [BFD] specifies a method for verifying unicast connectivity between a pair of systems. This document defines a method for using BFD to provide verification of multipoint or multicast connectivity between a multipoint sender (the "head") and a set of multipoint receivers (the "tails").

As multipoint transmissions are inherently unidirectional, this mechanism purports only to verify this unidirectional connectivity. Although this seems in conflict with the "Bidirectional" in BFD, it is a natural fit for that protocol.

This application of BFD allows for the tails to detect a lack of connectivity from the head. As an option, the tail may unreliably notify the head of the lack of multipoint connectivity. As a further option, this notification can be made reliable. Notification to the head can be enabled for all tails, or for only a subset of the tails.

Multipoint BFD verifies only the head-to-tail connectivity over the multipoint tree. Although it may use unicast paths in both directions, Multipoint BFD does not verify those paths (and in fact it is preferable if unicast paths share as little fate with the multipoint tree as is feasible.)

Virtually all options and timing parameters are controlled by the head. This is particularly important if head notifications are enabled, since there are obvious scaling concerns in that case.

Throughout this document, the term "multipoint" is defined as a mechanism by which more than one system receives packets sent by a single sender. This specifically includes such things as IP multicast and point-to-multipoint MPLS. The term "multipoint tree" includes degenerate cases such as LAN multicast.

This document effectively modifies and adds to the base BFD specification. It is the intention of the authors to fold these extensions into the base specification at the appropriate time.

## 2. Goals

The primary goal of this mechanism is to allow tails to rapidly detect the fact that multipoint connectivity from the head has failed. An optional goal is for the head to reasonably rapidly have knowledge of tails that have lost connectivity from the head.

Since scaling is a primary concern (particularly state implosion toward the head), it is a goal that the head be in control of all timing aspects of the mechanism, and that BFD packets from the tails to the head not be synchronized.

Another goal is for the mechanism to work on any multicast or multipoint medium.

A further goal is to support multiple, overlapping multipoint trees, as well as multipoint trees with multiple heads, and to allow point-to-point BFD sessions to operate simultaneously among the systems participating in Multipoint BFD.

A final goal is to integrate multipoint operation into the base specification in such a way as to make it relatively easy to support both multipoint and point-to-point operation in a single implementation.

It is a non-goal for this protocol to verify point-to-point connectivity between the head and any tails. This can be done independently (and with no penalty in protocol overhead) by using point-to-point BFD.

## 3. Overview

The heart of this protocol is the periodic transmission of BFD Control packets along a multipoint tree, from the head to all tails on the tree. The contents of the BFD packets provide the means for the tails to calculate the detection time for path failure. If no BFD Control packets are received by a tail for a detection time, the tail declares the path to have failed. For some applications this is the only mechanism necessary; the head can remain ignorant of the tails. In this mode, the tails never send any BFD traffic to the head.

If the head wishes to be alerted to the tails' connectivity (or lack thereof), there are a number of options. First, if all that is needed is an unreliable failure notification, the head can direct the tails to transmit unicast BFD Control packets back to the head when the path fails.

If the head wishes to know the identity of the tails on the multipoint tree, it may solicit membership by sending a multipoint BFD Control packet with the Poll (P) bit set, which will induce the tails to return a unicast BFD Control packet with the Final (F) bit set. The head can then create BFD session state for each of the tails that have multipoint connectivity. If the head sends such a packet on occasion, it can keep track of which tails answer, thus providing a somewhat reliable mechanism for detecting which tails fail to respond (implying a loss of multipoint connectivity.)

If the head wishes a reliable indication of the tails' connectivity, it may do all of the above, but if it detects that a tail did not answer the previous multipoint poll, it may initiate a Demand mode Poll Sequence as a unicast to the tail. This covers the case where either the multipoint poll or the single reply thereto is lost in transit. If desired, the head may Poll one or more tails proactively to track the tails' connectivity.

If some tails are more equal than others, in the sense that the head needs to detect the lack of multipoint connectivity to a subset of tails at a different rate, the head may transmit unicast BFD Polls to that subset of tails. In this case, the timing may be independent on a tail-by-tail basis.

Individual tails may be configured so that they never send BFD control packets to the head, even when the head wishes notification of path failure from the tail. Such tails will never be known to the head, but will still be able to detect multipoint path failures from the head.

Although this document describes a single head and a set of tails spanned by a single multipoint tree, the protocol is capable of supporting (and discriminating between) more than one multipoint tree at both heads and tails. Furthermore, the same head and tail may share multiple multipoint trees, and a multipoint tree may have multiple heads.

## 4. Protocol Details

This section describes the operation of Multipoint BFD in detail.

### 4.1. Multipoint BFD Control Packets

Multipoint BFD Control packets (packets sent by the head over a multipoint tree) are explicitly marked as such, via the setting of the M bit (added to the latest revision of the BFD base specification. This means that Multipoint BFD does not depend on the recipient of a packet to know whether the packet was received over a multipoint path. This can be useful in scenarios where this information may not be available to the recipient.

### 4.2. Session Model

Multipoint BFD is modeled as a set of sessions of different types. The elements of procedure differ slightly for each type.

Point-to-point sessions, as described in [BFD], are of type PointToPoint.

The head has a session of type MultipointHead that is bound to a multipoint tree. Multipoint BFD Control packets are sent by this session over the multipoint tree, and no BFD Control packets are received by it.

If the head is keeping track of some or all of the tails, it has a session of type MultipointClient per tail that it cares about. All of the MultipointClient sessions for tails on a particular particular multipoint tree are grouped with the MultipointHead session to which the clients are listening. A BFD Poll Sequence may be sent over such a session to a tail if the head wishes to verify connectivity. These sessions receive any BFD Control packets sent by the tails, and never transmit periodic BFD Control packets other than Poll Sequences (since periodic transmission is always done by the MultipointHead session.)

Each tail has a session of type MultipointTail associated with a multipoint tree. These sessions receive BFD Control packets from the head, both as multipoint packets (the MultipointHead session) and as unicast packets (the MultipointClient session, if it exists.) Any BFD Control packets sent to the head are sent over this session.

## 4.3. Session Failure Semantics

The semantics of session failure are subtle enough to warrant further explanation.

MultipointHead sessions cannot fail (since they are controlled administratively.)

If a MultipointTail session fails, it means that the tail definitely has lost contact with the head (or the head has been administratively disabled) and the tail should take appropriate action.

If a MultipointClient session receives a BFD Control packet from the tail with state Down or AdminDown, the head reliably knows that the tail has lost multipoint connectivity. If the Detection Time expires on a MultipointClient session, it is ambiguous as to whether the multipoint connectivity failed or whether there was a unicast path problem in one direction or the other, so the head does not reliably know the tail state.

## 4.4. State Variables

Multipoint BFD introduces some new state variables, and modifies the usage of a few existing ones.

### 4.4.1. New State Variables

A number of state variables are added to the base spec in support of Multipoint BFD.

bfd.SessionType

The type of this session. Allowable values are:

PointToPoint: Classic point-to-point BFD.

MultipointHead: A session on the head responsible for the periodic transmission of multipoint BFD Control packets

along the multipoint tree.

MultipointClient: A session on the head that tracks the state of an individual tail, when desirable.

MultipointTail: A multipoint session on a tail.

This variable MUST be initialized to the appropriate type when the session is created, according to the rules in section 4.16.

bfd.SilentTail

If 1, a tail will never transmit any BFD Control packets to the head under any circumstances. If 0, a tail may send packets to the head according to other parts of this specification. This allows tails to be provisioned to always be silent, even when the head is soliciting traffic from the tails. This can be useful, for example, in deployments of a large number of tails when the head wishes to track the state of a subset of them. This variable MUST be initialized based on configuration.

This variable is only pertinent when bfd.SessionType is MultipointTail.

bfd.ReportTailDown

Set to 1 if the head wishes tails to notify the head, via periodic BFD Control packets, when they see the BFD session fail. If 0, the tail will never send periodic BFD Control packets, and the head will not be notified of session failures by the tails. This variable MUST be initialized based on configuration.

This variable is only pertinent when bfd.SessionType is MultipointHead or MultipointClient.

bfd.UnicastRcvd

Set to 1 if a tail receives a unicast BFD Control packet from the head. This variable MUST be set to zero if the session transitions from Up state to some other state.

This variable MUST be initialized to zero.

This variable is only pertinent when Bfd.SessionType is

MultipointTail.

### 4.4.2. State Variable Initialization and Maintenance

Some state variables defined in section 6.8.1 of the BFD base spec need to be initialized or manipulated differently depending on the session type.

bfd.LocalDiscr

For session type MultipointClient, this variable MUST always match the value of bfd.LocalDiscr in the associated MultipointHead session.

bfd.DesiredMinTxInterval

For session type MultipointClient, this variable MUST always match the value of bfd.DesiredMinTxInterval in the associated MultipointHead session.

bfd.RequiredMinRxInterval

This variable MUST always be 0 for session type MultipointHead if bfd.ReportTailDown is 0.

It should be noted that for sessions of type MultipointTail, this variable only affects the rate of unicast Polls sent by the head; the rate of multipoint packets is necessarily unaffected by it.

bfd.DemandMode

This variable MUST be initialized to 1 for session types MultipointHead and MultipointClient, and MUST be initialized to 0 for session type MultipointTail.

bfd.DetectMult

For session type MultipointClient, this variable MUST always match the value of bfd.DetectMult in the associated MultipointHead session.

### 4.5. Controlling Multipoint BFD Options

The state variables defined above are used to choose which operational options are active.

The most basic form of operation, in which BFD Control packets flow only from the head and no tracking is desired of tail state at the head, is accomplished by setting bfd.ReportTailDown to 0 in the MultipointHead session.

If the head wishes to know the identity of the tails, it sends multipoint Polls as needed. Previously known tails that don't respond to the Polls will be detected.

If the head wishes to be notified by the tails when they lose connectivity, it sets bfd.ReportTailDown to 1 in either the MultipointHead session (if such notification is desired from all tails) or in the MultipointClient session (if notification is desired from a particular tail.) Note that the setting of this variable in a MultipointClient session for a particular tail overrides the setting in the MultipointHead session.

If the head wishes to verify the state of a tail on an ongoing basis, it sends a Poll Sequence from the MultipointClient session associated with that tail as needed.

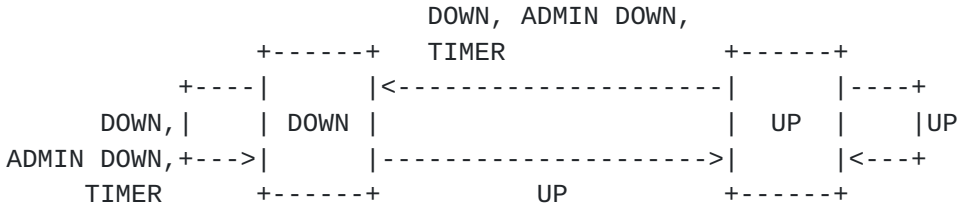
If the head wants to more quickly be alerted to a session failure from a particular tail, it sends a BFD Control packet from the MultipointClient session associated with that tail. This has the effect of eliminating the initial delay that the tail would otherwise insert prior to transmission of the packet.

If a tail wishes to operate silently (sending no BFD Control packets to the head) it sets bfd.SilentTail to 1 in the MultipointTail session. This allows a tail to be silent independent of the settings on the head.

### 4.6. State Machine

The BFD state machine works slightly differently in the multipoint application. In particular, since there is a many-to-one mapping, three-way handshakes for session establishment and teardown are neither possible nor appropriate. As such there is no Init state.

The following diagram provides an overview of the state machine for session types MultipointClient and MultipointTail. The notation on each arc represents the state of the remote system (as received in the State field in the BFD Control packet) or indicates the expiration of the Detection Timer.




Sessions of type MultipointHead never receive packets and have no Detection Timer, and as such all state transitions are administratively driven.

## 4.7. Session Establishment

Unlike Point-to-point BFD, Multipoint BFD provides a form of discovery mechanism for tails to discover the head, and vice versa. The minimum amount of a priori information required both on the head and tails is the binding to the multipoint tree over which BFD is running. The head transmits Multipoint BFD packets on that tree, and the tails listen for BFD packets on that tree. All other information MAY be determined dynamically.

A session of type MultipointHead is created for each multipoint tree over which the head wishes to run BFD. This session runs in the Active role. Except when terminating BFD service, this session is always in state Up and always operates in Demand mode. No received packets are ever demultiplexed to the MultipointHead session. In this sense it is a degenerate form of a session.

Sessions on the tail MAY be established dynamically, based on the receipt of a Multipoint BFD Control packet from the head, and are of type MultipointTail. Tail sessions always take the Passive role.

If BFD Control packets are received at the head, they are demultiplexed to sessions of type MultipointClient, which represent the set of tails that the head is interested in tracking. These sessions will typically also be established dynamically based on the receipt of BFD Control packets. The head has broad latitude in choosing which tails to track, if any, without affecting the basic operation of the protocol. The head directly controls whether or not tails are allowed to send BFD Control packets back to the head.

### 4.8. Discriminators and Packet Demultiplexing

The use of Discriminators is somewhat different in Multipoint BFD than in Point-to-point BFD.

The head sends Multipoint BFD Control packets over the MultipointHead session with My Discr set to a value bound to the multipoint tree, and with Your Discr set to zero. The tails MUST demultiplex these packets based on a combination of the source address and My Discr, which together uniquely identify the head and the multipoint tree.

When the tails send BFD Control packets to the head from the MultipointTail session, the contents of Your Discr (the discriminator received from the head) will not be sufficient for the head to demultiplex the packet, since the same value will be received from all tails on the multicast tree. In this case, the head MUST demultiplex packets based on the source address and the value of Your Discr, which together uniquely identify the tail and the multipoint tree.

When the head sends unicast BFD Control packets to a tail from a MultipointClient session, the value of Your Discr will be valid, and the tail MUST demultiplex the packet based solely on Your Discr.

Note that, unlike PointToPoint sessions, the discriminator values on all multipoint session types MUST NOT be changed during the life of a session. This is a side effect of the more complex demultiplexing scheme.

### 4.9. Controlling Tail Packet Transmission

As the fan-in from the tails to the head may be very large, it is critical that the flow of BFD Control packets from the tails is controlled.

The head always operates in Demand mode. This means that no tail will send an asynchronous BFD Control packet as long as the session is Up.

The value of Required Min Rx Interval received by a tail in a unicast BFD Control packet, if any, always takes precedence over the value received in Multipoint BFD Control packets. This allows the packet rate from individual tails to be controlled separately as desired by sending a BFD Control packet from the corresponding MultipointClient session. This also eliminates the random delay prior to transmission from the tail that would otherwise be inserted, reducing the latency of reporting a failure to the head.

If the head wishes to suppress traffic from the tails when they detect a session failure, it MAY set bfd.RequiredMinRxInterval to zero, which is a reserved value that indicates that the sender wishes to receive no periodic traffic. This can be set in the MultipointHead session (suppressing traffic from all tails) or it can be set in a MultipointClient session (suppressing traffic from only a single tail.)

Any tail may be provisioned to never send *any* BFD Control packets to the head by setting bfd.SilentTail to 1. This provides a mechanism by which only a subset of tails report their session status to the head.

### 4.10. Bringing Up and Shutting Down Multipoint BFD Service

Because there is no three-way handshake in Multipoint BFD, a newly started head (that does not have any previous state information available) SHOULD start with bfd.SessionState set to Down and with bfd.RequiredMinRxInterval set to zero in the MultipointHead session. The session SHOULD remain in this state for a time equal to (bfd.DesiredMinTxInterval * bfd.DetectMult). This will ensure that all MultipointTail sessions are reset (so long as the restarted head is using the same or larger value of bfd.DesiredMinTxInterval than it did previously.)

Multipoint BFD service is brought up by administratively setting bfd.SessionState to Up in the MultipointHead session.

A head may wish to shut down its BFD service in a controlled fashion. This is desirable because the tails need not wait a detection time prior to declaring the multipoint session to be down (and taking whatever action is necessary in that case.)

To shut down a multipoint session a head MUST administratively set bfd.SessionState in the MultipointHead session to either Down or AdminDown and SHOULD set bfd.RequiredMinRxInterval to zero (to keep the tails from sending any BFD Control packets back.) The session SHOULD send BFD Control packets in this state for a period equal to (bfd.DesiredMinTxInterval * bfd.DetectMult). The tail SHOULD destroy all MultipointClient sessions associated with the MultipointHead session.

The semantic difference between Down and AdminDown state is for further discussion.

### 4.11. Soliciting the Tails

If the head wishes to know the identities of the tails, the MultipointHead session MAY send a BFD Control packet as specified in section 4.16.3, with the Poll (P) bit set to 1. This will cause all of the tails to reply with a unicast BFD Control Packet, randomized across one packet interval.

The decision as to when to send a multipoint Poll is outside the scope of this specification. However, it must never be sent more often than the regular multipoint BFD Control packet. Since the tail will treat a multipoint Poll like any other multipoint BFD Control packet, Polls may be sent in lieu of non-Poll packets.

Soliciting the tails also starts the Detection Timer for each associated MultipointClient session, which will cause those sessions to time out if the associated tails do not respond.

Note that for this mechanism to work properly, the Detection Time (which is equal to bfd.DesiredMinTxInterval) MUST be greater than the round trip time of BFD Control packets from the head to the tail (via the multipoint tree) and back (via a unicast path.) See section 4.14 for more details.

### 4.12. Verifying Connectivity to Specific Tails

If the head wishes to verify connectivity to a specific tail, the corresponding MultipointClient session MAY send a BFD Poll Sequence to said tail. This might be done in reaction to the expiration of the Detection Timer (the tail didn't respond to a multipoint Poll), or it might be done on a proactive basis.

The interval between transmitted packets in the Poll Sequence MUST be calculated as specified in the base specification (the greater of bfd.DesiredMinTxInterval and bfd.RemoteMinRxInterval.)

The poll sequence is terminated the same way as for unicast BFD; if a reply from the tail with Final (F) set is received, the poll sequence is terminated, and if the poll sequence times out, the session with the tail is declared to be Down.

The value transmitted in Required Min RX Interval will be used by the tail (rather than the value received in any multipoint packet) when it transmits BFD Control packets to the head notifying it of a session failure, and the transmitted packets will not be delayed. This value can potentially be set much lower than in the multipoint case, in order to speed up notification to the head, since the value

will be used only by the single tail. This value (and the lack of delay) are "sticky", in that once the tail receives it, it will continue to use it indefinitely. Therefore, if the head no longer wishes to single out the tail, it SHOULD reset the timer to the default by sending a Poll Sequence with the same value of Required Min Rx Interval as is carried in the multipoint packets, or it MAY reset the tail session by sending a Poll Sequence with state AdminDown (after the completion of which the session will come back up.)

Note that a failure of the head to receive a response to a Poll Sequence does not necessarily mean that the tail has lost multipoint connectivity, though a reply to a Poll Sequence does reliably indicate connectivity or lack thereof (by virtue of the tail's state not being Up in the BFD Control packet.)

### 4.13. Timer Manipulation

Because of the one-to-many mapping, a session of type MultipointHead SHOULD NOT initiate a Poll Sequence in conjunction with timer value changes. As such, such a session cannot wait for a Final before increasing the transmit interval; such a session SHOULD send bfd.DetectMult packets at the old transmit interval before using the higher value in order to avoid false detection timeouts at the tails.

Since MultipointHead sessions do not calculate detection times, the value of bfd.RequiredMinRxInterval may be changed at any time.

### 4.14. Detection Times

Multipoint BFD is inherently asymmetric. As such, each session type has a different approach to detection times.

Since the MultipointHead session never receives packets, it does not calculate a detection time.

MultipointClient sessions at the head are always in Demand mode, and as such only care about detection time in two cases. First, if a Poll Sequence is being sent on a MultipointClient session, the detection time on this session is calculated according to the base spec, that is, the transmission interval multiplied by bfd.DetectMult. Second, when a multipoint Poll is sent to solicit tail replies, the detection time on all associated MultipointClient sessions that aren't currently sending Poll Sequences is set to a value greater than or equal to bfd.RequiredMinRxInterval (one packet time.) This value can be made arbitrarily large in order to ensure

that the detection time is greater than the BFD round trip time between the head and the tail with no ill effects, other than delaying the detection of unresponsive tails. Note that a detection time expiration on a MultipointClient session at the head, while indicating a BFD session failure, cannot be construed to mean that the tail is not hearing multipoint packets from the head.

MultipointTail sessions cannot influence the transmission rate of the MultipointHead session using the Required Min Rx Interval field because of its one-to-many nature. As such, the Detection Time calculation for a MultipointTail session does not use bfd.RequiredMinRxInterval in the calculation. The detection time is calculated as the product of the last received values of Desired Min TX Interval and Detect Mult.

The value of bfd.DetectMult may be changed at any time on any session type.

### 4.15. State Maintenance for Down/AdminDown Sessions

The length of time session state is kept after the session goes down determines how long the session will continue to send BFD Control packets (since no packets can be sent after the session is destroyed.)

#### 4.15.1. MultipointHead Sessions

When a MultipointHead session transitions to states Down or AdminDown, the state SHOULD be maintained for a period equal to (bfd.DesiredMinTxInterval * bfd.DetectMult) to ensure that the tails more quickly detect the session going down (by continuing to transmit BFD Control packets with the new state.)

#### 4.15.2. MultipointTail Sessions

If bfd.SilentTail is 1, or bfd.RemoteMinRxInterval is zero, MultipointTail sessions MAY be destroyed immediately upon leaving Up state, since they will transmit no further packets.

Otherwise, MultipointTail sessions MUST be maintained as long as BFD Control packets are being received by it (which by definition will indicate that the head is not Up.)

MultipointTail sessions MUST be maintained after a Detection Time expiration for at least the longer of an additional Detection Time

and the transmission of the first (delayed) BFD Control packet to the head. The state MAY be maintained longer than this, but the session MUST NOT transmit periodic BFD Control packets for a period longer than the negotiated transmit interval multiplied by bfd.DetectMult; after this time either the session MUST be destroyed or bfd.RemoteMinRxInterval MUST be set to zero to suppress packet transmission.

### 4.15.3. MultipointClient Sessions

If the MultipointHead session is going down (which only happens administratively), all associated MultipointClient sessions SHOULD be destroyed as they are superfluous.

If a MultipointClient session goes down due to the receipt of an unsolicited BFD Control packet from the tail with state Down or AdminDown (not in response to a Poll), and tail connectivity verification is not being done, the session MAY be destroyed. If verification is desired, the session SHOULD send a Poll Sequence and the session SHOULD be maintained.

If the tail replies to a Poll Sequence with state Down or AdminDown, it means that the tail session is definitely down. In this case, the session MAY be destroyed.

If the Detection Time expires on a MultipointClient session (meaning that the tail did not reply to a Poll Sequence) the session MAY be destroyed.

## 4.16. Base Specification Text Replacement

The following sections are meant to replace the corresponding sections in the base specification.

### 4.16.1. Reception of BFD Control Packets

The following procedure replaces section 6.8.6 of [BFD].

When a BFD Control packet is received, the following procedure MUST be followed, in the order specified. If the packet is discarded according to these rules, processing of the packet MUST cease at that point.

If the version number is not correct (1), the packet MUST be discarded.

If the Length field is less than the minimum correct value (24 if the A bit is clear, or 26 if the A bit is set), the packet MUST be discarded.

If the Length field is greater than the payload of the encapsulating protocol, the packet MUST be discarded.

If the Detect Mult field is zero, the packet MUST be discarded.

If the My Discriminator field is zero, the packet MUST be discarded.

Demultiplex the packet to a session according to section 4.16.2 below. The result is either a session of the proper type, or the packet is discarded (and packet processing MUST cease.)

If the A bit is set and no authentication is in use (bfd.AuthType is zero), the packet MUST be discarded.

If the A bit is clear and authentication is in use (bfd.AuthType is nonzero), the packet MUST be discarded.

If the A bit is set, the packet MUST be authenticated under the rules of section 6.7, based on the authentication type in use (bfd.AuthType.) This may cause the packet to be discarded.

Set bfd.RemoteDiscr to the value of My Discriminator.

Set bfd.RemoteState to the value of the State (Sta) field.

Set bfd.RemoteDemandMode to the value of the Demand (D) bit.

If bfd.SessionType is MultipointTail

   If bfd.UnicastRcvd is 0 or the M bit is clear, set bfd.RemoteMinRxInterval to the value of Required Min RX Interval.

   If the M bit is clear, set bfd.UnicastRcvd to 1.

Else (not MultipointTail)

   Set bfd.RemoteMinRxInterval to the value of Required Min RX Interval.

If the Required Min Echo RX Interval field is zero, the transmission of Echo packets, if any, MUST cease.

If a Poll Sequence is being transmitted by the local system and the Final (F) bit in the received packet is set, the Poll Sequence MUST be terminated.

If bfd.SessionType is PointToPoint or MultipointClient, update the transmit interval as described in [BFD] section 6.8.2.

If bfd.SessionType is PointToPoint, update the Detection Time as described in [BFD] section 6.8.4. Otherwise, update the Detection Time as described in section 4.14 above.

```
If bfd.SessionState is AdminDown
   Discard the packet

If received state is AdminDown
   If bfd.SessionState is not Down
      Set bfd.LocalDiag to 3 (Neighbor signaled session down)
      Set bfd.SessionState to Down

Else

   If bfd.SessionState is Down
      If bfd.SessionType is PointToPoint
         If received State is Down
            Set bfd.SessionState to Init
         Else if received State is Init
            Set bfd.SessionState to Up

      Else (bfd.SessionType is not PointToPoint)
         If received State is Up
            Set bfd.SessionState to Up

   Else if bfd.SessionState is Init
      If received State is Init or Up
         Set bfd.SessionState to Up

   Else (bfd.SessionState is Up)
      If received State is Down
         Set bfd.LocalDiag to 3 (Neighbor signaled session down)
         Set bfd.SessionState to Down
```

Check to see if Demand mode should become active or not (see [BFD] section 6.6).

If bfd.RemoteDemandMode is 1, bfd.SessionState is Up, and bfd.RemoteSessionState is Up, Demand mode is active on the remote system and the local system MUST cease the periodic transmission of BFD Control packets (see section 4.16.3.)

If bfd.RemoteDemandMode is 0, or bfd.SessionState is not Up, or bfd.RemoteSessionState is not Up, Demand mode is not active on the remote system and the local system MUST send periodic BFD Control packets (see section 4.16.3.)

If the Poll (P) bit is set, and bfd.SilentTail is zero, send a BFD Control packet to the remote system with the Poll (P) bit clear, and the Final (F) bit set (see section 4.16.3.)

If the packet was not discarded, it has been received for purposes of the Detection Time expiration rules in [BFD] section 6.8.4.

### 4.16.2. Demultiplexing BFD Control Packets

This section is part of the replacement for [BFD] section 6.8.6, separated for clarity.

If the Multipoint (M) bit is set

If the Your Discriminator field is nonzero, the packet MUST be discarded.

Select a session based on the source address and the My Discriminator field. If a session is found, and bfd.SessionType is not MultipointTail, the packet MUST be discarded. If a session is not found, a new session of type MultipointTail MAY be created, or the packet MAY be discarded. This choice is outside the scope of this specification.

Else (Multipoint bit is clear)

If the Your Discriminator field is nonzero

Select a session based on the value of Your Discriminator. If no session is found, the packet MUST be discarded.

If bfd.SessionType is MulticastHead

Select a session based on the source address and the value of Your Discriminator. If no session is found, a new session of type MultipointClient MAY be created, or the packet MAY be discarded. This choice is outside the scope of this specification.

If bfd.SessionType is not MulticastClient, the packet MUST be discarded.

Else (Your Discriminator is zero)

If the State field is not Down or AdminDown, the packet MUST be discarded.

Otherwise, the session MUST be selected based on some combination of other fields, possibly including source addressing information, the My Discriminator field, and the interface over which the packet was received. The exact method of selection is application-specific and is thus outside the scope of this specification.

If a matching session is found, and bfd.SessionType is not PointToPoint, the packet MUST be discarded.

If a matching session is not found, a new session of type PointToPoint may be created, or the packet may be discarded. This choice is outside the scope of this specification.

If the State field is Init and bfd.SessionType is not PointToPoint, the packet MUST be discarded.

### 4.16.3. Transmitting BFD Control Packets

The following procedure replaces section 6.8.7 of [BFD].

BFD Control packets MUST be transmitted periodically at the rate determined according to [BFD] section 6.8.2, except as specified in this section.

A system MUST NOT transmit any BFD Control packets if bfd.RemoteDiscr is zero and the system is taking the Passive role.

A system MUST NOT transmit any BFD Control packets if bfd.SilentTail is 1.

A system MUST NOT periodically transmit BFD Control packets if Demand mode is active on the remote system (bfd.RemoteDemandMode is 1, bfd.SessionState is Up, and bfd.RemoteSessionState is Up) and a Poll Sequence is not being transmitted.

A system MUST NOT periodically transmit BFD Control packets if bfd.RemoteMinRxInterval is zero.

A system MUST NOT periodically transmit BFD Control packets if bfd.SessionType is MulticastClient and a Poll Sequence is not being transmitted.

If bfd.SessionType is MultipointHead, the transmit interval MUST be set to bfd.DesiredMinTxInterval (this should happen automatically, as bfd.RemoteMinRxInterval will be zero.)

If bfd.SessionType is not MultipointHead, the transmit interval MUST be recalculated whenever bfd.DesiredMinTxInterval changes, or whenever bfd.RemoteMinRxInterval changes, and is equal to the greater of those two values. See [BFD] sections 6.8.2 and 6.8.3 for details on transmit timers.

If bfd.SessionType is MulticastTail and periodic transmission of BFD Control packets is just starting (due to Demand mode not being active on the remote system), the first packet to be transmitted MUST be delayed by a random amount of time between zero and (0.9 * bfd.RemoteMinRxInterval).

If a BFD Control packet is received with the Poll (P) bit set to 1, the receiving system MUST transmit a BFD Control packet with the Poll (P) bit clear and the Final (F) bit, without respect to the transmission timer or any other transmission limitations, without respect to the session state, and without respect to whether Demand mode is active on either system. A system MAY limit the rate at which such packets are transmitted. If rate limiting is in effect, the advertised value of Desired Min TX Interval MUST be greater than or equal to the interval between transmitted packets imposed by the rate limiting function. If the Multipoint (M) bit is set in the received packet, the packet transmission MUST be delayed by a random amount of time between zero and (0.9 * bfd.RemoteMinRxInterval). Otherwise, the packet MUST be transmitted as soon as practicable.

A system MUST NOT set the Demand (D) bit if bfd.SessionType is MultipointTail.

A system MUST NOT set the Demand (D) bit if bfd.SessionType is MultipointClient or PointToPoint unless bfd.DemandMode is 1, bfd.SessionState is Up, and bfd.RemoteSessionState is Up.

If bfd.SessionType is PointToPoint or MultipointHead, a BFD Control packet SHOULD be transmitted during the interval between periodic Control packet transmissions when the contents of that packet would differ from that in the previously transmitted packet (other than the Poll and Final bits) in order to more rapidly communicate a change in state.

The contents of transmitted BFD Control packets MUST be set as follows:

Version

Set to the current version number (1).

Diagnostic (Diag)

Set to bfd.LocalDiag.

State (Sta)

Set to the value indicated by bfd.SessionState.

Poll (P)

Set to 1 if the local system is sending a Poll Sequence or is a session of type MultipointHead soliciting the identities of the tails, or 0 if not.

Final (F)

Set to 1 if the local system is responding to a Control packet received with the Poll (P) bit set, or 0 if not.

Control Plane Independent (C)

Set to 1 if the local system's BFD implementation is independent of the control plane (it can continue to function through a disruption of the control plane.)

Authentication Present (A)

Set to 1 if authentication is in use on this session (bfd.AuthType is nonzero), or 0 if not.

Demand (D)

Set to bfd.DemandMode if bfd.SessionState is Up and bfd.RemoteSessionState is Up. Set to 1 if bfd.SessionType is MultipointHead or MultipointClient. Otherwise it is set to 0.

Multipoint (M)

Set to 1 if bfd.SessionType is MultipointHead. Otherwise it is set to 0.

Detect Mult

Set to bfd.DetectMult.

Length

Set to the appropriate length, based on the fixed header length (24) plus any Authentication Section.

My Discriminator

Set to bfd.LocalDiscr.

Your Discriminator

Set to bfd.RemoteDiscr.

Desired Min TX Interval

Set to bfd.DesiredMinTxInterval.

Required Min RX Interval

Set to bfd.RequiredMinRxInterval.

Required Min Echo RX Interval

Set to the minimum required Echo packet receive interval for this session. If this field is set to zero, the local system is unwilling or unable to loop back BFD Echo packets to the remote system, and the remote system will not send Echo packets.

Authentication Section

Included and set according to the rules in section 6.7 if authentication is in use (bfd.AuthType is nonzero.) Otherwise this section is not present.

## 5. Assumptions

If head notification is to be used, it is assumed that a multipoint BFD packet encapsulation contains enough information so that a tail can address a unicast BFD packet to the head.

If head notification is to be used, it is assumed that is that there is bidirectional unicast communication available (at the same protocol layer within which BFD is being run) between the tail and head.

For the head to know reliably that a tail has lost multipoint connectivity, the unicast paths in both directions between that tail and the head must remain operational when the multipoint path fails. It is thus desirable that unicast paths not share fate with the multipoint path to the extent possible if the head wants reliable knowledge of tail state.

Since the normal BFD three-way handshake is not used in this application, a tail transitioning from state Up to Down and back to Up again may not be reliably detected at the head.

If authentication is in use, all tails must be configured to have a common authentication key in order to receive the multipoint BFD Control packets.

## 6. Operational Scenarios

It is worth analyzing how this protocol reacts to various scenarios. There are three path components present, namely, the multipoint tree, the forward unicast path (from head to a particular tail), and the reverse unicast path (from a tail to the head.) There are also four options as to how the head is notified about failures from the tail.

### 6.1. No Head Notification

Since the only path used in this scenario is the multipoint tree, none of the others matter. A failure in the multipoint tree will result in the tail noticing the failure within a detection time, and the head will remain ignorant of the tail state.

### 6.2. Unreliable Head Notification

In this scenario, the tail sends back asynchronous BFD packets in response to the detection of a multipoint path failure. It uses the reverse unicast path, but not the forward unicast path.

If the multipoint path fails but the reverse unicast path stays up, the tail will detect the failure within a detection time, and the head will know about it within one reverse packet time (since the notification is delayed.)

If both the multipoint path and the reverse unicast paths fail, the tail will detect the failure but the head will remain unaware of it.

### 6.3. Semi-reliable Head Notification and Tail Solicitation

In this scenario, the head sends occasional multipoint Polls in addition to (or in lieu of) non-Poll multipoint BFD Control packets, expecting the tails to reply with Final. This also uses the reverse unicast path, but not the forward unicast path.

If the multipoint path fails but the reverse unicast path stays up, the tail will detect the failure within a detection time, and the head will know about it within one reverse packet time (the notification is delayed to avoid synchronization of the tails.)

If both the multipoint path and the reverse unicast paths fail, the tail will detect the failure but the head will remain unaware of this fact.

If the reverse unicast path fails but the multipoint path stays up, the head will see the BFD session fail, but the state of the multipoint path will be unknown to the head. The tail will continue to receive multipoint data traffic.

If either the multipoint Poll or the unicast reply is lost in transit, the head will see the BFD session fail, but the state of the multipoint path will be unknown to the head. The tail will continue to receive multipoint data traffic.

### 6.4. Reliable Head Notification

In this scenario, the head sends occasional multipoint Polls in addition to (or in lieu of) non-Poll multipoint BFD control packets, expecting the tails to reply with Final. If a tail that had previously replied to a multipoint Poll fails to reply (or if the head simply wishes to verify tail connectivity,) the head issues a unicast Poll Sequence to the tail. This scenario makes use of all three paths.

If the multipoint path fails but the two unicast paths stay up, the tail will detect the failure within a detection time, and the head will know about it within one reverse packet time (since the notification is delayed.) Note that the reverse packet time may be smaller in this case if the head has previously issued a unicast Poll (since the tail will not delay transmission of the notification in this case.)

If both the multipoint path and the reverse unicast paths fail (regardless of the state of the forward unicast path), the tail will detect the failure but the head will remain unaware of this fact. The head will detect a BFD session failure to the tail but cannot make a determination about the state of the tail's multipoint connectivity.

If the forward unicast path fails but the reverse unicast path stays up, the head will detect a BFD session failure to the tail if it happens to send a unicast Poll sequence, but cannot make a determination about the state of the tail's multipoint connectivity. If the multipoint path to the tail fails prior to any unicast Poll being sent, the tail will detect the failure within a detection time, and the head will know about it within one reverse packet time (since the notification is delayed.)

If the multipoint path stays up but the reverse unicast path fails, the head will see the BFD session fail if it happens to send a Poll Sequence, but the state of the multipoint path will be unknown to the head. The tail will continue to receive multipoint data traffic.

If the multipoint path and the reverse unicast path both stay up but the forward unicast path fails, neither side will notice so long as a unicast Poll Sequence is never sent by the head. If the head sends a unicast Poll Sequence, the head will see the BFD session fail, but the state of the multipoint path will be unknown to the head. The tail will continue to receive multipoint data traffic.

## 7. IANA Considerations

This document has no actions for IANA.

## 8. Security Considerations

This specification does not raise any additional security issues beyond those of the specifications referred to in the list of normative references.

## 9. Normative References

[BFD] Katz, D., and Ward, D., "Bidirectional Forwarding Detection", draft-ietf-bfd-base-09.txt, February, 2009.

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Changes from the previous draft

This is a reissue of the previous version. There are only minor editorial changes.

This document expires in August, 2009.