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BFD for Multipoint Networks
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Abstract

This document describes extensions to the Bidirectional Forwarding Detection (BFD) protocol for its use in multipoint and multicast networks.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on October 20, 2018.

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1. Introduction

The Bidirectional Forwarding Detection protocol [RFC5880] 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 one or more 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, the protocol is capable supporting this use case.

This application of BFD allows for the tails to detect a lack of connectivity from the head. Due to unidirectional nature, virtually all options and timing parameters are controlled by the head.

As an option, the tail may notify the head of the lack of multipoint connectivity. Details of tail notification to the head are outside the scope of this document.

Throughout this document, the term "multipoint" is defined as a mechanism by which one or more systems receive packets sent by a single sender. This specifically includes such things as IP multicast and point-to-multipoint MPLS.

Term "connectivity" in this document is not being used in the context of connectivity verification in transport network but as an alternative to "continuity", i.e. existence of a forwarding path between the sender and the receiver.

This document effectively modifies and adds to the base BFD specification [RFC5880].

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.

Another goal is for the mechanism to work on any multicast technology.

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

It is not a goal for this protocol to verify point-to-point bi-directional connectivity between the head and any tail. 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 path, 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 having failed. For some applications this is the only mechanism necessary; the head can remain ignorant of the tails.

The head of a multipoint BFD session may wish to be alerted to the tails' connectivity (or lack thereof). Details of how the head keeps track of tails and how tails alert their connectivity to the head are outside scope of this document.

Although this document describes a single head and a set of tails spanned by a single multipoint path, the protocol is capable of supporting (and discriminating between) more than one multipoint path at both heads and tails, as described in Section 4.7 and Section 4.13.2. Furthermore, the same head and tail may share multiple multipoint paths, and a multipoint path 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 path) are explicitly marked as such, via the setting of the M bit [RFC5880]. 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.

The head has a session of type MultipointHead, as defined in Section 4.4.1, that is bound to a multipoint path. Multipoint BFD Control packets are sent by this session over the multipoint path, and no BFD Control packets are received by it.

Each tail has a session of type MultipointTail, as defined in Section 4.4.1, associated with a multipoint path. These sessions receive BFD Control packets from the head over the multipoint path.

4.3. Session Failure Semantics

The semantics of session failure is 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.

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 Variable Values

A number of new values of the state variable bfd.SessionType are added to the base BFD [RFC5880] and base S-BFD [RFC7880] specifications in support of Multipoint BFD.

bfd.SessionType

The type of this session as defined in [RFC7880]. Newly added values are:

PointToPoint: Classic point-to-point BFD, as described in [RFC5880].

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

MultipointTail: A multipoint session on a tail.

This variable MUST be initialized to the appropriate type when the session is created.

4.4.2. State Variable Initialization and Maintenance

Some state variables defined in section 6.8.1 of [RFC5880] need to be initialized or manipulated differently depending on the session type.

bfd.RequiredMinRxInterval

This variable MUST be initialized to 0 for session type MultipointHead.

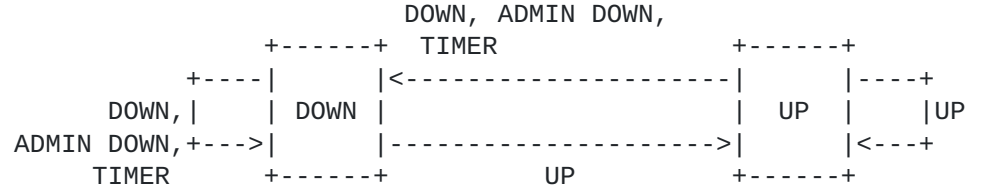
bfd.DemandMode

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

4.5. 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. Sessions of type MultipointHead MUST NOT send BFD control packets with the State field being set to INIT, and those packets MUST be ignored on receipt.

The following diagram provides an overview of the state machine for session type 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.

4.6. Session Establishment

Unlike point-to-point BFD, Multipoint BFD provides a form of the discovery mechanism for tails to discover the head. The minimum amount of a priori information required both on the head and tails

is

binding to the multipoint path 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 path over which the head wishes to run BFD. This session runs in the Active role , per section 6.1 [RFC5880]. Except when administratively 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, per section 6.1 [RFC5880].

4.7. 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 multipoint path via the MultipointHead session with My Discr set to a value bound to the multipoint path, and with Your Discr set to zero.

IP and MPLS multipoint tails MUST demultiplex BFD packets based on a combination of the source address, My Discriminator and the identity of the multipoint tree which the Multipoint BFD Control packet was received from. Together they uniquely identify the head of the multipoint path. Bootstrapping BFD session to multipoint MPLS LSP in case of penultimate hop popping is outside the scope of this document.

Note that, unlike point-to-point sessions, the My Discriminator value on MultipointHead session MUST NOT be changed during the life of a session. This is a side effect of the more complex demultiplexing scheme.

4.8. Packet consumption on tails

BFD packets received on tails for an IP multicast group MUST be consumed by tails and MUST NOT be forwarded to receivers. Node with the BFD session of type MultipointTail MUST identify packet received on an IP multipoint path as BFD control packet if the destination UDP port value equals 3784.

For multipoint LSPs, when IP/UDP encapsulation of BFD control packets is used, MultipointTail MUST expect destination UDP port 3784. Destination IP address of BFD control packet MUST be in 127.0.0.0/8 range for IPv4 or in 0:0:0:0:0:FFFF:7F00:0/104 range for IPv6. The use of these destination addresses is consistent with the explanations and usage in [RFC8029]. Packets identified as BFD packets MUST be consumed by MultipointTail and demultiplex as described in Section 4.13.2. Use of other types of encapsulation of the BFD control message over multipoint LSP is outside the scope of this document.

4.9. 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 bfd.RequiredMinRxInterval MUST be 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 a 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.

The head of a multipoint BFD session 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 the head MUST administratively set bfd.SessionState in the MultipointHead session to either Down or AdminDown and SHOULD set bfd.RequiredMinRxInterval to zero. The session SHOULD send BFD Control packets in this state for a period equal to (bfd.DesiredMinTxInterval * bfd.DetectMult).

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

4.10. 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. However, to indicate a change in the packets, MultipointHead session MUST send packets with the P bit set.

MultipointTail session MUST NOT reply if the packet has M and P bits set and bfd.RequiredMinRxInterval set to 0.

The MultipointHead, when changing the transmit interval to a higher value, MUST send BFD control packets with P bit set at the old transmit interval before using the higher value in order to avoid false detection timeouts at the tails. MultipointHead session MAY also wait some amount of time before making the changes to the transmit interval (through configuration).

Change in the value of bfd.RequiredMinRxInterval is outside the scope of this document.

4.11. Detection Times

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

Since MultipointHead sessions never receive packets, they do not calculate a detection time.

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.

4.12. 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).

4.12.1. 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).

4.12.2. MultipointTail Sessions

MultipointTail sessions MAY be destroyed immediately upon leaving Up state, since tail will transmit no packets.

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

4.13. Base Specification Text Replacement

The following sections are meant to replace the corresponding sections in the base specification [RFC5880] in support of BFD for multipoint networks while not changing processing for point-to-point BFD.

4.13.1. Reception of BFD Control Packets

The following procedure replaces section 6.8.6 of [RFC5880].

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 4.13.2 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 [RFC5880] 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.

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, update the transmit interval as described in [RFC5880] section 6.8.2.

If bfd.SessionType is PointToPoint, update the Detection Time as described in section 6.8.4 of [RFC5880]. If bfd.SessionType is MultipointTail, then update the Detection Time as the product of the last received values of Desired Min TX Interval and Detect Mult, as described in Section 4.11 of this specification.

If bfd.SessionState is AdminDown

Discard the packet

If the 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 [RFC5880] 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 4.13.3).

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 4.13.3).

If the packet was not discarded, it has been received for purposes of the Detection Time expiration rules in [RFC5880] section 6.8.4.

4.13.2. Demultiplexing BFD Control Packets

This section is part of the replacement for [RFC5880] 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 as based on source address, My Discriminator and the identity of the multipoint tree which the Multipoint BFD Control packet was received. 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.

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.

4.13.3. Transmitting BFD Control Packets

The following procedure replaces section 6.8.7 of [RFC5880].

BFD Control packets MUST be transmitted periodically at the rate determined according to [RFC5880] 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.SessionType is MultipointTail.

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.

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 [RFC5880] sections 6.8.2 and 6.8.3 for details on transmit timers.

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 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 in 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. 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 0 if bfd.SessionType is MultipointHead or MultipointTail.

Authentication Section

Included and set according to the rules in [RFC5880] section 6.7 if authentication is in use (bfd.AuthType is nonzero). Otherwise, this section is not present.

5. Assumptions

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. IANA Considerations

This document has no actions for IANA.

7. Security Considerations

The same security considerations as those described in [RFC5880] apply to this document. Additionally, implementations that create MultpointTail sessions dynamically upon receipt of Multipoint BFD Control packets MUST implement protective measures to prevent an

infinite number of MultipointTail sessions being created. Below are listed some points to be considered in such implementations.

If a Multipoint BFD Control packet did not arrive on a multicast tree (e.g. on the expected interface, with expected MPLS label, etc), then a MultipointTail session should not be created.

If redundant streams are expected for a given multicast stream, then the implementations should not create more MultipointTail sessions than the number of streams. Additionally, when the number of MultipointTail sessions exceeds the number of expected streams, then the implementation should generate an alarm to users to indicate the anomaly.

The implementation should have a reasonable upper bound on the number of MultipointTail sessions that can be created, with the upper bound potentially being computed based on the number of multicast streams that the system is expecting.

8. Contributors

Rahul Aggarwal of Juniper Networks and George Swallow of Cisco Systems provided the initial idea for this specification and contributed to its development.

9. Acknowledgments

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