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Multicast On-path Telemetry Solutions
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Abstract

This document discusses the requirement of on-path telemetry for multicast traffic. The existing solutions are examined and their issues are identified. Solution modifications are proposed to allow the original multicast tree to be correctly reconstructed without unnecessary replication of telemetry information.

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.

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[1.](#) Introduction

Multicast traffic is an important traffic type in today's Internet. Multicast provides services that are often real time (e.g., online meeting) or have strict QoS requirements (e.g., IPTV, Market Data). Multicast packet drop and delay can severely affect the application performance and user experience.

It is important to monitor the performance of the multicast traffic. Existing OAM techniques cannot gain direct and accurate information about the multicast traffic. New on-path telemetry techniques such as In-situ OAM [[I-D.ietf-ippm-ioam-data](#)], Postcard-based Telemetry

[[I-D.song-ippm-postcard-based-telemetry](#)], and Hybrid Two-Step (HTS) [[I-D.mirsky-ippm-hybrid-two-step](#)] provide promising means to directly monitor the network experience of multicast traffic. However, multicast traffic has some unique characteristics which pose some challenges on efficiently applying such techniques.

When a network contains multicast (p2mp) trees there will be redundant data as data is replicated at branch points. The IP Multicast S,G data is identical from one branch to another on it's way to multiple receivers. When adding iOAM trace data, to multicast packets, we enlarge data packets thus consuming more network bandwidth. Instead of adding iOAM trace data, it could be more efficient to collect the telemetry information using solutions, such as iOAM postcard or HTS, to cut down on the redundant iOAM data. The problem is that a postcard type solution doesn't have a branch identifier.

This draft proposes a set of solutions to this iOAM data redundancy problem. The requirements for multicast traffic telemetry are discussed along with the issues of the existing on-path telemetry techniques. We propose modifications to make these techniques adapt to multicast in order for the original multicast tree to be correctly reconstructed while eliminating redundant data.

2. Requirements for Multicast Traffic Telemetry

Multicast traffic is forwarded through a multicast tree. With PIM and P2MP (MLDP, RSVP-TE) the forwarding tree is established and maintained by the multicast routing protocol. With BIER, no state is created in the network to establish a forwarding tree, instead, a bier header provides the necessary information for each packet to know the egress points. Multicast packets are only replicated at each tree branch node for efficiency.

There are several requirements for multicast traffic telemetry, a few of which are:

- o Reconstruct and visualize the multicast tree through data plane monitoring.
- o Gather the multicast packet delay and jitter performance.
- o Find the multicast packet drop location and reason.
- o Gather the VPN state and tunnel information in case of P2MP multicast.

In order to meet these requirements, we need the ability to directly monitor the multicast traffic and derive data from the multicast packets. The conventional OAM mechanisms, such as multicast ping and trace, may not be sufficient to meet these requirements.

3. Issues of Existing Techniques

On-path Telemetry techniques that directly retrieve data from multicast traffic's live network experience are ideal to address the above mentioned requirements. The representative techniques include In-situ OAM (IOAM) Trace option [[I-D.ietf-ippm-ioam-data](#)], IOAM Direct Export (DEX) option [[I-D.ioamteam-ippm-ioam-direct-export](#)], and Postcard-based Telemetry with Packet Marking(PBT-M) [[I-D.song-ippm-postcard-based-telemetry](#)]. However, unlike unicast, multicast poses some unique challenges to applying these techniques.

Multicast packets are replicated at each branch node in the corresponding multicast tree. Therefore, there are multiple copies of packets in the network.

If the IOAM trace option is used for on-path data collection, the partial trace data will also be replicated into multiple copies. The end result is that each copy of the multicast packet has a complete trace. Most of the data, however, is redundant. Data redundancy introduces unnecessary header overhead, wastes network bandwidth, and complicates the data processing. In case the multicast tree is large, and the path is long, the redundancy problem becomes severe.

The PBT solutions, including the IOAM DEX option and PBT-M, can be used to eliminate such data redundancy, because each node on the tree only sends a postcard covering local data. However, they cannot track the tree branches properly so it can bring confusion about the multicast tree topology. For example, Node A has two branches, one to Node B and the other to node D, and Node B leads to Node C and Node D leads to Node E. From the received postcards, one cannot tell whether or not Node C(E) is the next hop of Node B(D).

The fundamental reason for this problem is that there is not an identifier (either implicit or explicit) to correlate the data on each branch.

4. Proposed Modifications to Existing Techniques

Two solutions are proposed to address the above issues. One is built on PBT and requires augmentation or modification to the instruction header of the IOAM Direct Export Option; the other combines the IOAM trace option and PBT for an optimized solution.

4.1. Per-hop postcard using IOAM DEX

One way to mitigate PBT's multiple tree tracking weakness is to augment it with a branch identifier field. Note that this works for the IOAM DEX option but not for PBT-M because the IOAM DEX option uses an instruction header. To make the branch identifier globally unique, the branch node ID plus an index is used. For example, if Node A has two branches, one to Node B and one to Node C, Node A will use [A, 0] as the branch identifier for the branch to B, and [A, 1] for the branch to C. The identifier is unchanged for each multicast tree instance and carried with the multicast packet until the next branch node. Each postcard needs to include the branch identifier in the export data. The branch identifier, along with the other fields such as flow ID and sequence number, is sufficient for the data analyzer to reconstruct the topology of the multicast tree.

Figure 1 shows an example of this solution. "P" stands for the postcard packet. The square brackets contains the branch identifier. The curly brace contains the telemetry data about a specific node.

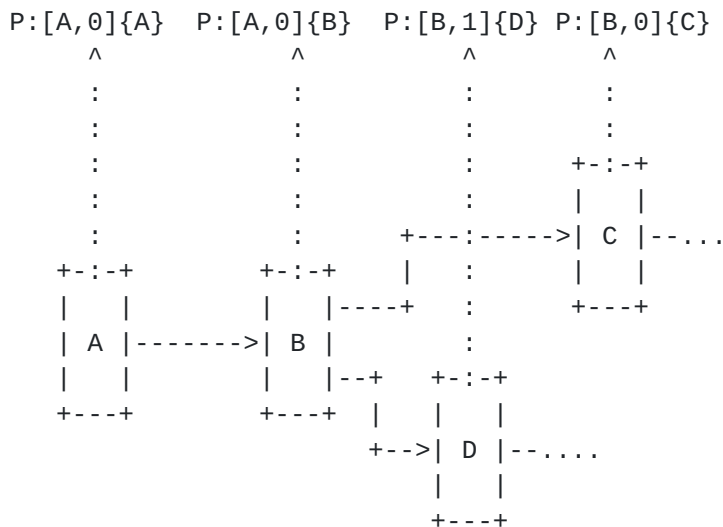


Figure 1: Per-hop Postcard

Each branch fork node need to generate the branch ID for each branch in its multicast tree instance and include it in the IOAM DEX option header so the downstream node can learn it. The branch ID contains two parts: the branch fork node ID and a unique branch index.

Figure 2 shows that the branch ID is carried as an optional field after the flow ID and sequence number optional fields in the IOAM DEX option header. A bit "M" in the Flags field is reserved to indicate

the presence of the branch index field. The "M" flag position will be determined later after the other flags are specified in [\[I-D.ioamteam-ippm-ioam-direct-export\]](#).

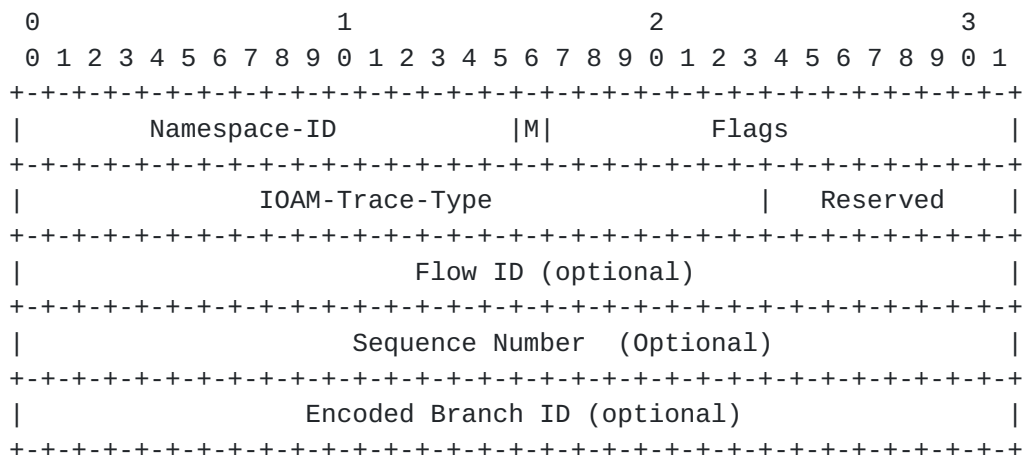


Figure 2: Carry Branch Index in IOAM DEX option header

To avoid introducing a new type of data field to the IOAM DEX option header, we can encode the branch identifier using the existing node ID data field as defined in [\[I-D.ietf-ippm-ioam-data\]](#). Currently, the node ID field occupies three octets. A simple solution is to shorten the node ID field so a number of bits can be saved to encode the branch index, as shown in Figure 3.

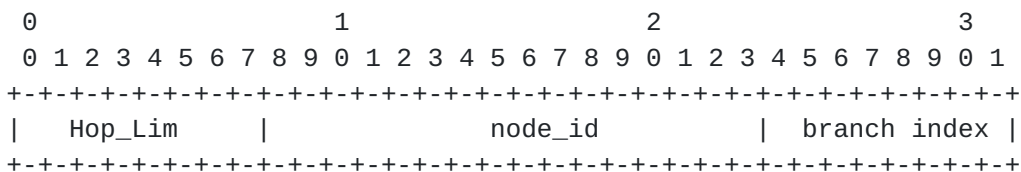


Figure 3: Encode Branch Index with Node ID Method 1

Another encoding method is to use the sum of the node ID and the branch index as the new node ID, as shown in Figure 4. As long as the node IDs are assigned with large enough gap, the telemetry data analyzer can still successfully recover the original node ID and branch index.

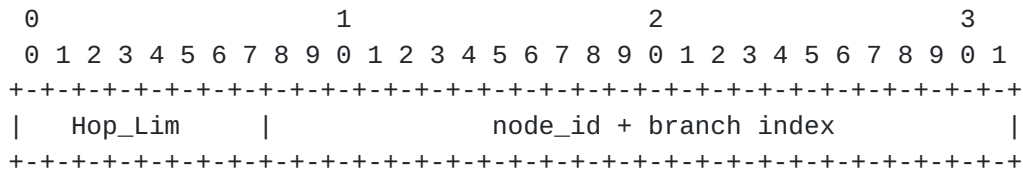


Figure 4: Encode Branch Index with Node ID Method 2

Once a node gets the branch ID information from the upstream, it MUST carry this information in its telemetry data export postcards, so the original multicast tree can be correctly reconstructed based on the postcards.

4.2. Per-section postcard

The second solution is a combination of the IOAM trace mode and PBT. To avoid data redundancy at each branch node, the trace data accumulated, to that point, is exported by a postcard before the packet is replicated. In this case, each branch still needs to maintain some identifier to help correlate the postcards for each tree section. The natural way to accomplish this is to simply carry the branch node's data (including its ID) in the trace of each branch. This is also necessary because each replicated multicast packet can have different telemetry data pertaining to this particular copy (e.g., node delay, egress timestamp, and egress interface). As a consequence, the local data exported by each branch node can only contain partial data (e.g., ingress interface and ingress timestamp).

Figure 5 shows an example in a segment of a multicast tree. Node B and D are two branch nodes and they will export a postcard covering the trace data for the previous section. The end node of each path will also need to export the data of the last section as a postcard.

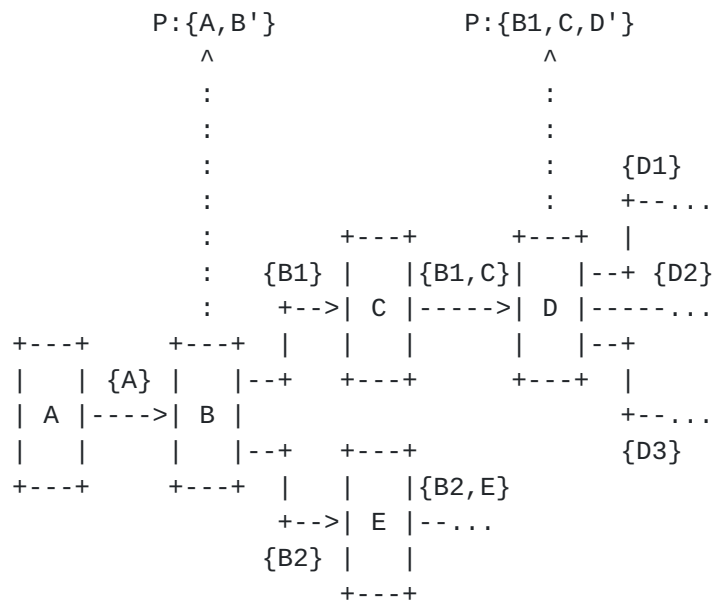


Figure 5: Per-section Postcard

There is no need to modify the IOAM trace mode header format. We just need to configure the branch node to export the postcard and refresh the IOAM header and data.

5. Considerations for Different Multicast Protocols

MTRACEv2 [[RFC8487](#)] provides an active probing approach for the tracing of an IP multicast routing path. Mtrace can also provide information such as the packet rates and losses, as well as other diagnostic information. New on-path telemetry techniques will enhance Mtrace, and other existing OAM solutions, with more granular and realtime network status data through direct measurements. There are various multicast protocols that are used to forward the multicast data. Each will require their own unique on-path telemetry solution.

5.1. Application in PIM

PIM-SM [[RFC7761](#)] is the most widely used multicast routing protocol deployed today. Of the various PIM modes (PIM-SM, PIM-DM, BIDIR-PIM, PIM-SSM), PIM-SSM is the preferred method due to its simplicity and removal of network source discovery complexity. With all PIM modes, control plane state is established in the network in order to forward multicast UDP data packets. But with PIM-SSM, the discovery of multicast sources is performed outside of the network via HTTP, SDN, etc. IP Multicast packets fall within the range of 224.0.0.0 through

239.255.255.255. The telemetry solution will need to work within this address range and provide telemetry data for this UDP traffic.

The proposed solutions for encapsulating the telemetry instruction header and metadata in IPv4/IPv6 UDP packets are described in [\[I-D.herbert-ipv4-udpencap-eh\]](#) and [\[I-D.ioametal-ippm-6man-ioam-ipv6-deployment\]](#).

5.2. Application in P2MP

Multicast Label Distribution Protocol (MLDP) and P2MP RSVP-TE are commonly used within a Multicast VPN (MVPN) environment. MLDP provides extensions to LDP to establish point-to-multipoint (P2MP) and multipoint-to-multipoint (MP2MP) label switched paths (LSPs) in MPLS networks. P2MP RSVP-TE provides extensions to RSVP-TE for establish traffic-engineered P2MP LSPs in MPLS networks. The telemetry solution will need to be able to follow these P2MP paths. The telemetry instruction header and data should be encapsulated into MPLS packets on P2MP paths. A corresponding proposal is described in [\[I-D.song-mpls-extension-header\]](#).

5.3. Application in BIER

BIER [\[RFC8279\]](#) adds a new header to multicast packets and allows the multicast packets to be forwarded according to the header only. By eliminating the requirement of maintaining per multicast group state, BIER is more scalable than the traditional multicast solutions.

OAM Requirements for BIER [\[I-D.ietf-bier-oam-requirements\]](#) lists many of the requirements for OAM at the BIER layer which will help in the forming of on-path telemetry requirements as well.

There is also current work to provide solutions for BIER forwarding in ipv6 networks. For instance, a solution, BIER in Non-MPLS IPv6 Networks [\[I-D.xie-bier-ipv6-encapsulation\]](#), proposes a new bier Option Type codepoint from the "Destination Options and Hop-by-Hop Options" IPv6 sub-registry. This is similar to what IOAM proposes for IPv6 transport.

Depending on how the BIER header is encapsulated into packets with different transport protocols, the method to encapsulate the telemetry instruction header and metadata also varies. It is also possible to make the instruction header and metadata a part of the BIER header itself, such as in a TLV.

6. Security Considerations

No new security issues are identified other than those discovered by the IOAM and PBT drafts.

7. IANA Considerations

The document makes no request of IANA.

8. Contributors

TBD

9. Acknowledgments

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