BIER Working Group
Internet-Draft
Intended status: Standards Track
Expires: May 23, 2021

G. Mirsky
ZTE Corp.
T. Przygienda
Juniper Networks
A. Dolganow
Individual contributor

November 19, 2020

# Path Maximum Transmission Unit Discovery (PMTUD) for Bit Index Explicit Replication (BIER) Layer

draft-ietf-bier-path-mtu-discovery-09

## Abstract

This document describes Path Maximum Transmission Unit Discovery (PMTUD) in Bit Indexed Explicit Replication (BIER) layer.

## Status of This Memo

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## 1. Introduction

In packet switched networks, when a host seeks to transmit data to a target destination, the data is transmitted as a set of packets. In many cases, it is more efficient to use the largest size packets that are less than or equal to the least Maximum Transmission Unit (MTU) for any forwarding device along the routed path to the IP destination for these packets. Such "least MTU" is known as Path MTU (PMTU). Fragmentation or packet drop, silent or not, may occur on hops along the route where an MTU is smaller than the size of the datagram. To avoid any of the listed above behaviors, the packet source must find the value of the least MTU, i.e., PMTU, that will be encountered along the route that a set of packets will follow to reach the given set of destinations. Such MTU determination along a specific path is referred to as path MTU discovery (PMTUD).

[RFC8279] introduces and explains Bit Index Explicit Replication (BIER) architecture and how it supports the forwarding of multicast data packets. A BIER domain consists of Bit-Forwarding Routers (BFRs) that are uniquely identified by their respective BFR-ids. An ingress border router (acting as a Bit Forwarding Ingress Router (BFIR)) inserts a Forwarding Bit Mask (F-BM) into a packet. Each targeted egress node (referred to as a Bit Forwarding Egress Router (BFER)) is represented by Bit Mask Position (BMP) in the BMS. A transit or intermediate BIER node, referred to as BFR, forwards BIER encapsulated packets to BFERs, identified by respective BMPs, according to a Bit Index Forwarding Table (BIFT).

### 1.1. Conventions used in this document

#### 1.1.1. Acronyms

BFR: Bit-Forwarding Router

BFER: Bit-Forwarding Egress Router

BFIR: Bit-Forwarding Ingress Router

BIER: Bit Index Explicit Replication

BIFT: Bit Index Forwarding Tree

F-BM: Forwarding Bit Mask

MTU: Maximum Transmission Unit

OAM: Operations, Administration and Maintenance

PMTUD: Path MTU Discovery

#### 1.1.2. 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.

## 2. Problem Statement

[I-D.ietf-bier-oam-requirements] sets forth the requirement to define PMTUD protocol for BIER domain. This document describes the extension to [I-D.ietf-bier-ping] for use in the BIER PMTUD solution.

Current PMTUD mechanisms ([RFC1191], [RFC8201], and [RFC4821]) are primarily targeted to work on point-to-point, i.e. unicast paths. These mechanisms use packet fragmentation control by disabling fragmentation of the probe packet. As a result, a transient node that cannot forward a probe packet that is bigger than its link MTU sends to the packet source an error notification, otherwise the packet destination may respond with a positive acknowledgment. Thus, possibly through a series of iterations, varying the size of the probe packet, the packet source discovers the PMTU of the particular path.

Thus applied such existing PMTUD solutions are inefficient for point-to-multipoint paths constructed for multicast traffic. Probe packets must be flooded through the whole set of multicast distribution paths over and over again until the very last egress responds with a positive acknowledgment. Consider without loss of generality an example multicast network presented in Figure 1, where MTU on all links but one (B, D) is the same. If MTU on the link (B, D) is smaller than the MTU on the other links, using existing PMTUD mechanism probes will unnecessary flood to leaf nodes E, F, and G for the second and consecutive times and positive responses will be generated and received by root A repeatedly.

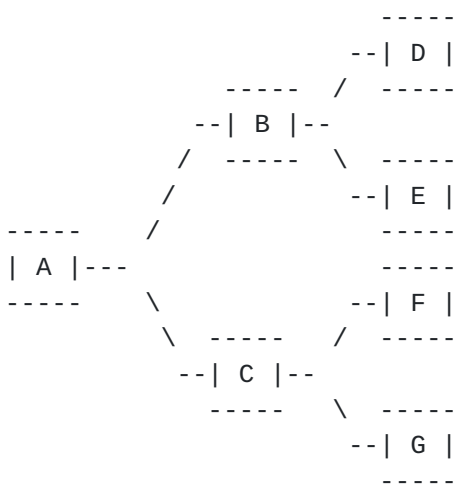


Figure 1: Multicast network

## 3. PMTUD Mechanism for BIER

A BFIR selects a set of BFERs for the specific multicast distribution. Such a BFIR determines, by explicitly controlling a subset of targeted BFERs and transmitting a series of probe packets, the MTU of that multicast distribution tree. In the case of ECMP, BFIR MAY test each path by variating the value in the Entropy field. The critical step is that in case of failure at an intermediate BFR to forward towards the subset of targeted downstream BFERs, the BFR responds with a partial (compared to the one it received in the request) bitmask towards the originating BFIR in error notification. That allows for retransmission of the next probe with a smaller MTU address only towards the failed downstream BFERs instead of all BFERs addressed in the previous probe. In the scenario discussed in Section 2 the second and all following (if needed) probes will be sent only to the node D since MTU discovery of E, F, and G has been completed already by the first probe successfully.

[I-D.ietf-bier-ping] introduced BIER Ping as a transport-independent OAM mechanism to detect and localize failures in the BIER data plane. This document specifies how BIER Ping can be used to perform efficient PMTUD in the BIER domain.

Consider the network displayed in Figure 1 to be a presentation of a BIER domain and all nodes to be BFRs. To discover MTU over BIER domain to BFERs D, F, E, and G BFIR A will use BIER Ping with Data TLV, defined in Section 3.1. Size of the first probe set to M_max determined as minimal MTU value of BFIR's links to BIER domain. As has been assumed in Section 2, MTUs of all links but the link (B, D) are the same. Thus BFERs E, F, and G would receive BIER Echo Request and will send their respective replies to BFIR A. BFR B may pass the packet which is too large to forward over egress link (B, D) to the appropriate network layer for error processing where it would be recognized as a BIER Echo Request packet. BFR B MUST send BIER Echo Reply to BFIR A and MUST include Downstream Mapping TLV, defined in [I-D.ietf-bier-ping] setting its fields in the following fashion:

- MTU SHOULD be set to the minimal MTU value among all egress BIER links, logical links between this and downstream BFRs, that could be used to reach B's downstream BFERs;

- Address Type MUST be set to 0 [Ed.note: we need to define 0 as valid value for the Address Type field with the specific semantics to "Ignore" it.]

- I flag MUST be cleared;

- Downstream Interface Address field (4 octets) MUST be zeroed and MUST include in the Egress Bitstring sub-TLV the list of all BFERs that cannot be reached because the attempted MTU turned out to be too small.

The BFIR will receive either of the two types of packets:

- a positive Echo Reply from one of BFERs to which the probe has been sent. In this case, the bit corresponding to the BFER MUST be cleared from the BMS;

- a negative Echo Reply with bit string listing unreached BFERs and recommended MTU value MTU'. The BFIR MUST add the bit string to its BMS and set the size of the next probe as min(MTU, MTU')

If upon expiration of the Echo Request timer BFIR didn't receive any Echo Replies, then the size of the probe SHOULD be decreased. There are scenarios when an implementation of the PMTUD would not decrease the size of the probe. For example, suppose upon expiration of the

Echo Request timer BFIR didn't receive any Echo Reply. In that case, BFIR MAY continue to retransmit the probe using the initial size and MAY apply probe delay retransmission procedures. The algorithm used to delay retransmission procedures on BFIR is outside the scope of this specification. The BFIR sends probes using BMS and locally defined retransmission procedures until either the bit string is clear, i.e., contains no set bits, or until the BFIR retransmission procedure terminates and PMTU discovery is declared unsuccessful. In the case of convergence of the procedure, the size of the last probe indicates the PMTU size that can be used for all BFERs in the initial BMS without incurring fragmentation.

Thus we conclude that in order to comply with the requirement in [I-D.ietf-bier-oam-requirements]:

- a BFR SHOULD support PMTUD;
- a BFR MAY use defined per BIER sub-domain MTU value as initial MTU value for discovery or use it as MTU for this BIER sub-domain to reach BFERs;
- a BFIR MUST have a locally defined PMTUD probe retransmission procedure.

### 3.1. Data TLV for BIER Ping

There needs to be a control for probe size in order to support the BIER PMTUD. Data TLV format is presented in Figure 2.

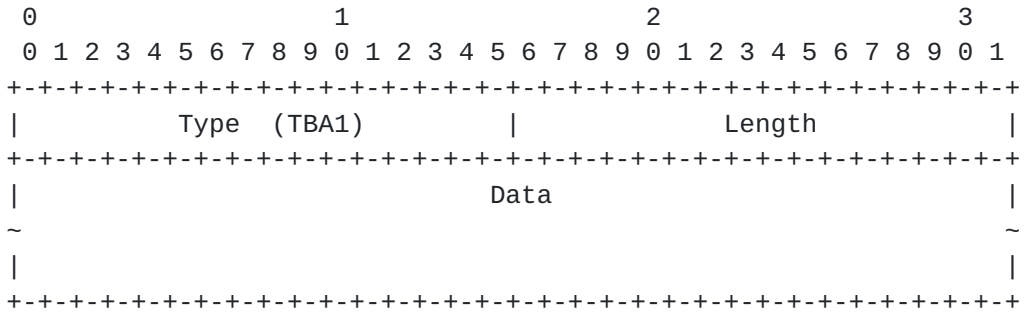


Figure 2: Data TLV format

- Type: indicates Data TLV, to be allocated by IANA Section 4.
- Length: the length of the Data field in octets.
- Data: n octets (n = Length) of arbitrary data. The receiver SHOULD ignore it.

## 4. IANA Considerations

IANA is requested to assign a new Type value for Data TLV Type from its registry of TLV and sub-TLV Types of BIER Ping as follows:

| Value | Description | Reference |
|---|---|---|
| TBA1 | Data | This document |

Table 1: Data TLV Type

## 5. Security Considerations

Routers that support PMTUD based on this document are subject to the same security considerations as defined in [I-D.ietf-bier-ping]

## 6. Acknowledgment

Authors greatly appreciate thorough review and the most detailed comments by Eric Gray.

## 7. References

### 7.1. Normative References

[I-D.ietf-bier-ping]
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[RFC8201] McCann, J., Deering, S., Mogul, J., and R. Hinden, Ed., "Path MTU Discovery for IP version 6", STD 87, RFC 8201, DOI 10.17487/RFC8201, July 2017, <https://www.rfc-editor.org/info/rfc8201>.

## 7.2. Informative References

[I-D.ietf-bier-oam-requirements] Mirsky, G., Nainar, N., Chen, M., and S. Pallagatti, "Operations, Administration and Maintenance (OAM) Requirements for Bit Index Explicit Replication (BIER) Layer", draft-ietf-bier-oam-requirements-11 (work in progress), November 2020.

[RFC8279] Wijnands, IJ., Ed., Rosen, E., Ed., Dolganow, A., Przygienda, T., and S. Aldrin, "Multicast Using Bit Index Explicit Replication (BIER)", RFC 8279, DOI 10.17487/RFC8279, November 2017, <https://www.rfc-editor.org/info/rfc8279>.

## Authors' Addresses

Greg Mirsky
ZTE Corp.

Email: gregimirsky@gmail.com

Tony Przygienda
Juniper Networks

Email: prz@juniper.net

Andrew Dolganow
Individual contributor

Email: adolgano@gmail.com