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Operations, Administration and Maintenance (OAM) for Network Resource Partition (NRP) in MPLS Network

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Abstract

A Network Resource Partition (NRP) represents a subset of network resources and associated policies within the underlay network.

This document describes the implementation of the Operations, Administration, and Maintenance (OAM) mechanism for NRPs in MPLS networks. By extending existing OAM mechanisms such as ping, traceroute, the proposed solution enables comprehensive NRP support in MPLS networks.

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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Table of Contents

1. Introduction

[RFC9543] provides the definition of IETF network slice for use within the IETF and discusses the general framework for requesting and operating IETF Network Slices, their characteristics, and the necessary system components and interfaces. It also introduces the concept Network Resource Partition (NRP), which is a subset of the resources and associated policies in the underlay network.

Using OAM tools enables real-time monitoring of the operational status of network slices, allowing for quick detection and localization of faults. When a node or link within a network slice experiences a failure, OAM tools can promptly issue alerts, assisting network administrators in taking swift corrective action to minimize service downtime. Therefore, the use of OAM tools in an NRP network is crucial for ensuring the availability and performance of network slice resources. This not only enhances user experience but also improves the overall efficiency and stability of the network.

Existing OAM tools typically include Ping, Traceroute. [RFC8029] describes how to Detect MPLS Data-Plane Failures in MPLS networks.

This document continues to employ these existing OAM mechanisms to monitor Data-Plane NRP resources Failures.

1.1. 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. OAM Mechanisms

[RFC8029] describes how to Detect MPLS Data-Plane Failures in MPLS networks.

During the process of using existing OAM mechanisms to check the operational status of NRP resources, the OAM initiator needs to carry the NRP-ID in the data plane of the inspection packets.

Intermediate equipment and OAM End Points need to check the availability of NRP resources when receiving OAM packets with an NRP-ID. If the NRP resources are unavailable, they should respond to the OAM initiator with an error message, indicating that the NRP resources are unavailable.

This document adopts these existing methods of carrying the NRP-ID in the data plane to perform OAM operations within NRP networks. The specific mechanisms for carrying the NRP-ID in the data plane are outside the scope of this document. Based on different underlying networks, this document describes how to use OAM tools to monitor NRP resources by carrying the NRP-ID during OAM operations.

Building on the aforementioned aspects, using existing OAM mechanisms for underlay network operations and existing mechanisms for carrying the NRP-ID in the data plane, this document will describe how to use OAM tools to monitor the operational status of NRP resources within NRP networks.

3. MPLS PING

When performing a MPLS PING operation, the initiator sends a MPLS Echo request. To support the probing of NRP resources, NRP

information is carried in the data layer. Intermediate nodes inspect the NRP resources. If the request packet can be forwarded to the control plane, the response packet can include an error code to notify the initiator of an "NRP resource unavailable" error. However, if the packet cannot be forwarded to the control plane, the request packet is simply dropped, and the initiator cannot obtain specific error information.

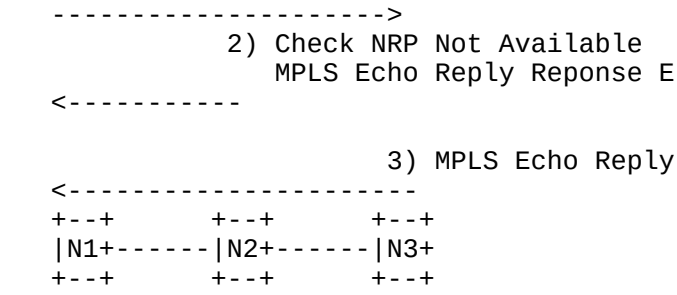

Figure 1 MPLS PING for NRP

Process of MPLS PING for NRP:

1) The initiator of the MPLS Echo Request includes the NRP-ID in the data layer when sending the MPLS PING request.

2) The intermediate node or End Point first checks if the NRP resources are available when processing a MPLS Echo Request. If they are not available, it responds with a MPLS Echo Reply, indicating the Error as "NRP resources unavailable".

   For MPLS networks, it is necessary to extend the Return Codes carried in the MPLS Echo Reply(IANA 8.1).

3) If the check passes, the End Point will respond with a normal MPLS Echo Reply.

4. MPLS TRACEROUTE

When performing a MPLS TRACEROUTE operation, the TRACEROUTE initiator sends MPLS Echo request packets toward the destination node by incrementally increasing the TTL value. To support the probing of NRP resources, NRP information is carried in the data layer. Each intermediate node first checks the availability of NRP resources before inspecting the TTL. If the resources are unavailable, the node responds with an MPLS Echo Reply with error message indicating NRP resource unavailability. The packets used for

MPLS TRACEROUTE are the same as those used for MPLS PING. When NRP resources are unavailable, the error codes used are also identical to those used in MPLS PING operations

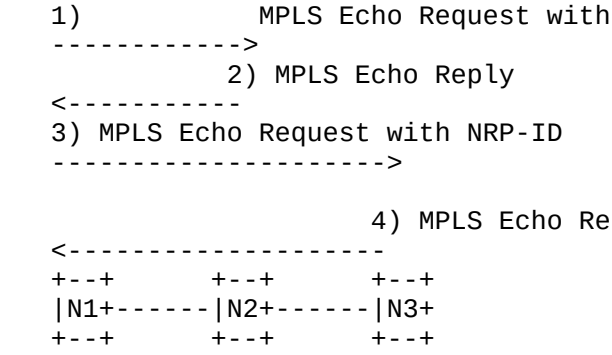

Figure 2 MPLS Traceroute for NRP

Process of MPLS Traceroute for NRP:

1) The initiator of the MPLS Echo request includes the NRP-ID in the data layer when sending the Traceroute request.

   The MPLS Echo Request with TTL 1 to n increase.

2) The intermediate node or End Point first checks if the NRP resources are available when processing a MPLS Echo Request. If they are not available, it responds with a MPLS Echo Reply, indicating the Error as "NRP resources unavailable". The error code for expansion should be the same as MPLS PING.

3) If the check passes, the process proceeds with a normal MPLS Traceroute, performing hop-by-hop detection of the path to the End Point until the Traceroute process is completed, and the detection results are outputted.

5. UseCase

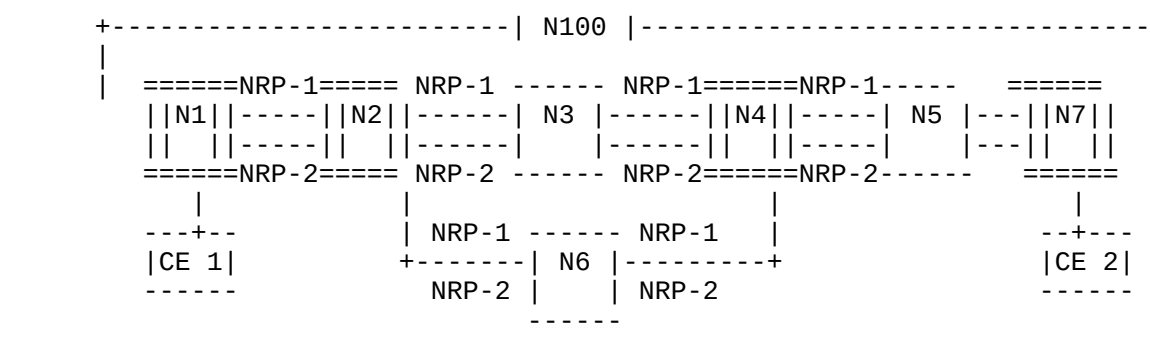

Figure 5 NRP network diagram

As illustrated In the reference topology of Figure 1,

Node j has a IPv4 loopback address 192.168.j.1/32

A LABEL at node j is 1j000.

Node N100 is a controller.

5.1. MPLS PING

An example of MPLS Ping success:

> ping 15000 via label-stack 12000, 14000, NRP-ID: 1, Ret NRP-ID: 2

Sending 5, 100-byte MPLS Echos to 192.168.5.2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 0.625 /0.749/0.931 ms

An example of MPLS Ping failure due to NRP resource unavailability:

> ping 15000 via label-stack 12000, 14000, NRP-ID: 1, Ret NRP-ID: 2

Reply to request 2 (1 ms). Return Code: ’N’

Reply to request 3 (1 ms). Return Code: ’N’

Reply to request 4 (1 ms). Return Code: ’N’

Reply to request 3 (1 ms). Return Code: ’N’

Reply to request 4 (1 ms). Return Code: ’N’

Success rate is 0 percent (0/5), round-trip min/avg/max = 1/1/1 ms

Error code ’N’ indicates that the cause of the error is the unavailability of NRP resources. This explanation applies to the following examples as well and will not be reiterated.

5.2. MPLS TRACEROUTE

An example of MPLS traceroute success:

> traceroute 15000 via label-stack 12000, 14000, NRP-ID: 1, Ret-NRP-ID: 2

Tracing the route to 15000

1 192.168.2.1 [MPLS: Label 12000] 1.123 ms 1.045 ms 1.067 ms

2 192.168.4.1 [MPLS: Label 14000] 1.123 ms 1.045 ms 1.067 ms

2 192.168.5.1 [MPLS: Label 15000] 1.123 ms 1.045 ms 1.067 ms

An example of MPLS traceroute failure due to NRP resource unavailability:

> traceroute 15000 via label-stack 12000, 14000, NRP-ID: 1, Ret-NRP-ID: 2

Tracing the route to 15000

1 192.168.2.1 [MPLS: Label 12000] Return Code: ’N’

6. Security Considerations

This document does not impose any additional security challenges to be considered beyond the security threats described in [RFC4884], [RFC4443], [RFC0792], [RFC8754], and [RFC8986].

7. IANA Considerations

7.1. MPLS Reply Error Code

IANA is requested to allocated new Return Codes "Return Subcode" registry.

Value	Meaning
TBD	NRP resource unavailable

8. References

8.1. Normative References

[RFC9543] Farrel, A., Ed., Drake, J., Ed., Rokui, R., Homma, S., Makhijani, K., Contreras, L., and J. Tantsura, "A Framework for Network Slices in Networks Built from IETF Technologies", RFC 9543, DOI 10.17487/RFC9543, March 2024, <https://www.rfc-editor.org/info/rfc9543>.

[RFC8029] K. Kompella, Juniper Networks, Inc., G. Swallow, C. Pignataro, Ed., N. Kumar, Cisco, S. Aldrin, Google, M. Chen, Huawei, "Detecting Multiprotocol Label Switched (MPLS) Data-Plane Failures", RFC 8029, DOI 10.17487/RFC8029, March 2017, <https://www.rfc-editor.org/info/rfc8029>.

8.2. Informative References

TBD

Acknowledgements

TBD

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