NOKIA

7450 Ethernet Service Switch
7750 Service Router
7950 Extensible Routing System
Virtualized Service Router

Releases up to 25.7.R2

OAM and Diagnostics Advanced Configuration Guide for MD-CLI

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Preface

About This Guide

Each Advanced Configuration Guide is organized alphabetically and provides feature and configuration explanations, CLI descriptions, and overall solutions. The Advanced Configuration Guide chapters are written for and based on several Releases, up to 25.7.R2. The Applicability section in each chapter specifies on which release the configuration is based.

The Advanced Configuration Guides supplement the user configuration guides listed in the *7450 ESS, 7750 SR, and 7950 XRS Guide to Documentation*.

Audience

This manual is intended for network administrators who are responsible for configuring the routers. It is assumed that the network administrators have a detailed understanding of networking principles and configurations.

Lawful Interception

This chapter provides information about lawful interception.

Topics in this chapter include:

- Applicability
- Overview
- Configuration
- Conclusion

Applicability

The information and the configuration in this chapter are based on SR OS Release 22.2.R1. Lawful interception (LI) is supported in MD-CLI in SR OS Release 19.10.R1 and later.

Overview

This chapter provides configuration examples to commission LI in MD-CLI and does not serve the purpose to provide LI architectural or configuration recommendations.

Basic knowledge of the SR OS LI architecture is required.

Figure 1: Lawful interception shows a high-level diagram depicting the mechanism.

Figure 1: Lawful interception
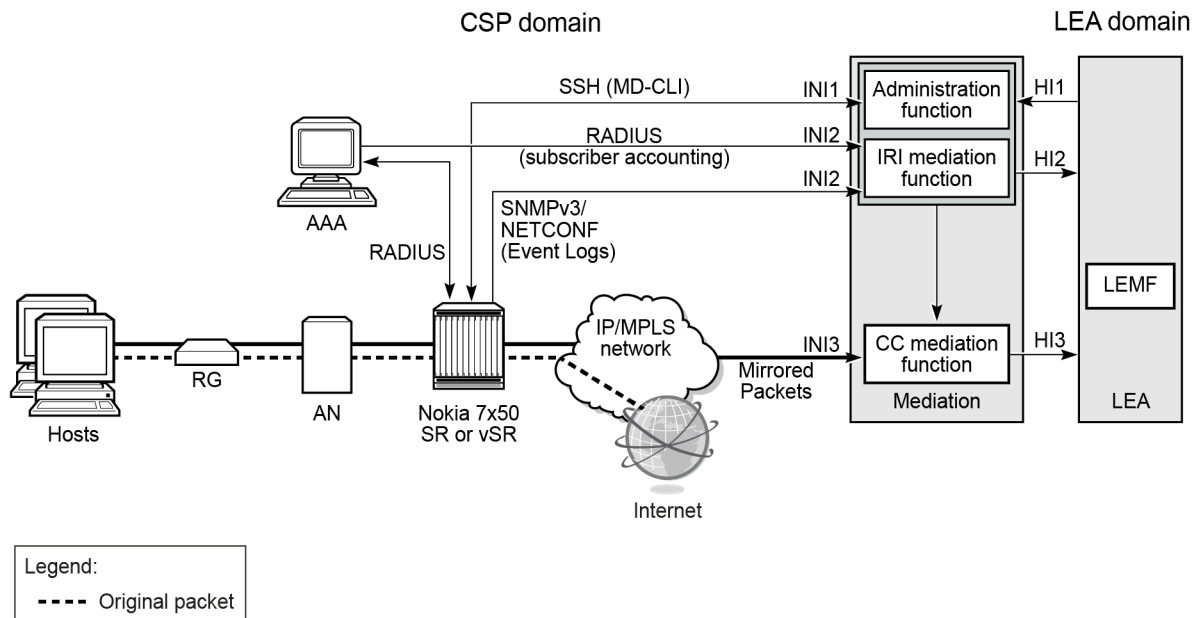
where:

- CSP: communications service provider
- RG: residential gateway
- AN: access network
- IRI: intercept related information
- CC: content of communication
- LEA: law enforcement agency
- LEMF: law enforcement monitoring facilities

The mediation element depicted in Figure 1: Lawful interception is used to normalize various vendors' INI interfaces to standardized HI interfaces for the LEMF. The industry uses various terms for the mediation element such as LI Mediation (LIM), Mediation Device (MD), and LI Gateway (LIG). For the remainder to this chapter, the term LIG will be used to refer to the mediation element.

Configuration

First, the network administrator commissions the system for LI and afterward, the LI administrator provisions the LI sources.

Network administrator commissions the system for LI

The procedure to commission the system for LI includes the following steps:

- Create a local AAA profile for LI administration access
- Create local LI administrators including their access, method of access, and local AAA profile
- Create a mirror destination for copied packets where the destination address is the LI gateway
- [Optional] Update the boot option file (BOF) configuration:
  - [Option 1] Enable LI separate in the BOF. This configuration allows only users with LI access rights to be able to access the LI configuration region. All other user types are locked out of the LI configuration region.
  - [Option 2] Enable LI local save. The configuration enables the system to save the running LI configuration into the flash as an encrypted file.

  Either one or both of the options can be enabled. Changing configuration flags in the BOF requires a reboot to take effect.

When the local LI administrator is configured and after an optional update of the BOF configuration and a reboot, an LI administrator can access the LI configuration region.

The different steps in the procedure to commission the system for LI are described in more detail in the following sections.

Create a local AAA profile for LI

An LI user and profile must be configured before the LI separate flag is enabled in the BOF.

The local AAA profile "li" is created, as follows:

```
[pr:/configure system security aaa local-profiles]
A:admin@latest-BNG2# info
    profile "li" {
    }
```

The following is an example of some common entries for the LI profile:

```
[pr:/configure system security aaa local-profiles profile "li"]
A:admin@latest-BNG2# info
    default-action deny-all
    entry 10 {
        action permit
        match "edit-config li exclusive"
    }
    entry 20 {
        action permit
        match "li"
    }
    entry 30 {
        action permit
        match "show li"
    }
    entry 40 {
        action permit
        match "admin save li"
    }
    entry 50 {
        action permit
        match "quit-config"
    }
    entry 60 {
```

```
        action permit
        match "edit-config private"
    }
    entry 70 {
        action permit
        match "configure system security user-params local-user"
    }
    entry 80 {
        action permit
        match "tools perform security"
    }
    entry 90 {
        action permit
        match "show li"
    }
    entry 100 {
        action permit
        match "commit"
    }
    entry 110 {
        action permit
        match "validate"
    }
    entry 120 {
        action permit
        match "admin save"
    }
    entry 130 {
        action permit
        match "info"
    }
    entry 140 {
        action permit
        match "back"
    }
```

Create a local LI administrator

LI administrators are local users and are associated with the configured LI profile. In the following example, local LI administrator "liadmin" is created.

```
!(pr)[/configure system security user-params local-user]
A:admin@latest-BNG2# info
    user "liadmin" {
        password "$2y$10$tKCwYWx/m9uffwGCJIYls.vh/340TU3Rn6RR1Qxt2zEQPlUOIAJJG"
        access {
            console true
            netconf true
            li true
        }
        console {
            member ["li"]
        }
    }
```

Create a mirror destination for LI use

In this example, the mirror destination uses an LI IP UDP shim header, as shown in Figure 2: Shim header format.

Figure 2: Shim header format

Field	Bits	Values
version	4	1
direction	1	ingress = 0 egress = 1
mirror type	1	ethernet = 0 ip-only = 1
filter action	1	drop = 0 accept = 1
inter-ref-type	1	if-index = 0 sap-instance-id = 1
interface	24	interface-value

IP
UDP
SHIM
mirrored packet
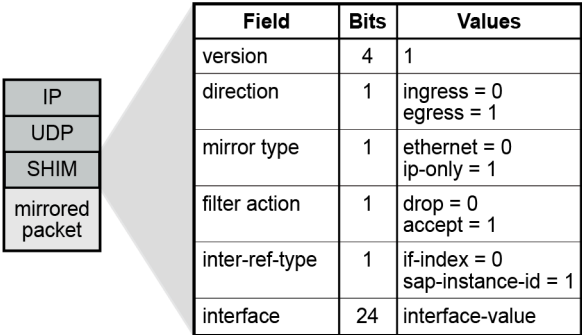
40253

The mirror destination routing instance is a VPRN with ID 1. The LI Gateway (LIG) is at 192.168.2.1 while the source IP address placed into the outer IP header of the copied packets is 192.168.1.1. Both source and destination UDP port use 11111. The header used is IP UDP shim (which allows an LI header to indicate the intercept ID, the session ID, and the direction of the mirrored packet).

```
!(pr)[/configure mirror]
A:admin@latest-BNG2# info
    mirror-dest "1" {
        admin-state enable
        encap {
            layer-3-encap {
                header-type ip-udp-shim
                direction-bit true
                router-instance "1"
                gateway {
                    ip-address {
                        source 192.168.1.1
                        destination 192.168.2.1
                    }
                    udp-port {
                        source 11111
                        destination 11111
                    }
                }
            }
        }
    }
```

Update BOF configuration (optional)

The BOF offers two configuration options for LI:

- **li separate**
- and **li local-save**

The **li separate** option separates the LI configuration region access from the normal administrator. The requirement of separating LI access is typically determined by local jurisdictions.

```
*[pr:/bof]
A:admin@latest-BNG2# info
    li {
        separate true
    }
```

A system reboot is required for any changes to **li separate** to take effect.

```
A:admin@eng-BNG-2# admin save bof

A:admin@latest-BNG2# /admin reboot now
```

The **li local-save** option allows the LI configuration to be saved to persistent storage (for example, on a compact flash device) locally on the system.

> **Note:** The permission to store the LI configuration locally on the system is typically determined by local jurisdictions.

```
*[pr:/bof]
A:admin@latest-BNG2# info
    li {
        local-save true
    }
```

A system reboot is required for any changes to **li local-save** to take effect.

```
A:admin@eng-BNG-2# admin save bof
A:admin@latest-BNG2# /admin reboot now
```

> **Note:** The **li separate**option and the **li local-save** option can be performed together and therefore require only one reboot. The configuration is as follows.

```
*[pr:/bof]
A:admin@latest-BNG2# info
    li {
        separate true
        local-save true
    }
```

A system reboot is required for any changes to **li separate** or to **li local-save** to take effect.

```
A:admin@eng-BNG-2# admin save bof
A:admin@latest-BNG2# /admin reboot now
```

Log in as the LI administrator and edit the LI configuration

When the LI administrator is created (and, optionally, the BOF is updated and the system is rebooted), the LI configuration region is accessible to the LI administrator. When the LI administrator logs in as the "liadmin" user, the prompt shows "liadmin" as the user:

```
A:liadmin@latest-BNG2#
```

The following command is used to edit the LI configuration:

```
A:liadmin@latest-BNG2# edit-config li exclusive
```

The **li** option is needed to edit the LI configuration region. The LI administrator has the choice to configure in private or exclusive mode. For more information about private and exclusive configuration mode, see the *7450 ESS, 7750 SR, 7950 XRS, and VSR MD-CLI User Guide*. Nokia recommends to use **exclusive** mode for LI configuration to allow one LI administrator at a time to make LI configuration changes.

Additional LI infrastructure setup

When the system is commissioned with LI users and a LIG mirror destination for LI, the LI administrator provisions the rest of the LI infrastructure pieces. The following configuration examples are described:

- Update the LI administrator password
- [Optional] Create additional local LI users
- Configure the LI log, for the Intercept Related Information (IRI) interface, either using SNMPv3 or NETCONF
- Associate the LI source to the mirror destination, for mirroring to the Content of Communication (CC) Interface
- Add an LI source object to contain future LI targets

The preceding steps are described in more detail in the following sections.

Update the LI administrator password

The normal non-LI network administrator created the LI administrator user account including the password . The LI administrator should change the password the first time that they log in. The following command changes the LI administrator password. In this example, the LI administrator is "liadmin" and an example new password is configured. Note that the new password is not a recommended password, but just an example for illustration.

```
[/]
A:liadmin@latest-BNG2# password
Enter current password: TheInitialPassword
Enter new password: NewSecretPassword
Re-enter new password: NewSecretPassword
```

Add additional LI users to the system (optional)

The LI administrator creates new LI users including the username and password first in the main config region. In this example, the LI administrator has created two additional local user accounts: "liuser1" and "liuser2" with profile "li-user" which has less access rights compared to an li admin, as follows:

```
!(pr)[/configure system security user-params local-user]
A:admin@latest-BNG2# info
    user "liuser1" {
        password "UpdateThis"
        access {
            console true
            netconf true
            li true
        }
        console {
            member ["li-user"]
        }
    }
    user "liuser2" {
        password "UpdateThis"
        access {
            console true
            netconf true
            li true
        }
        console {
            member ["li-user"]
        }
    }
```

The following is an example of an LI profile for li-user. Compared to the profile "li" used for LI administrator users, this "li-user" profile does not contain entry 70. This difference in the profiles ensures that non-administrator LI users cannot edit or create other users.

```
[pr:/configure system security aaa local-profiles profile "li-user"]
A:admin@latest-BNG2# info
    default-action deny-all
    entry 10 {
        action permit
        match "edit-config li exclusive"
    }
    entry 20 {
        action permit
        match "li"
    }
    entry 30 {
        action permit
        match "show li"
    }
    entry 40 {
        action permit
        match "admin save li"
    }
    entry 50 {
        action permit
        match "quit-config"
    }
    entry 60 {
        action permit
```

```
                match "edit-config private"
            }
            entry 80 {
                action permit
                match "tools perform security"
            }
            entry 90 {
                action permit
                match "show li"
            }
            entry 100 {
                action permit
                match "commit"
            }
            entry 110 {
                action permit
                match "validate"
            }
            entry 120 {
                action permit
                match "admin save"
            }
            entry 130 {
                action permit
                match "info"
            }
            entry 140 {
                action permit
                match "back"
            }
```

Afterward, the new LI users log in using the password provided for them and they should change the password using the following command. Note that the new password is not a recommended password, but just an example for illustration.

```
[/]
A:liuser1@latest-BNG2# password
Enter current password: TheInitialUser1Password
Enter new password: NewSecretUser1Password
Re-enter new password: NewSecretUser1Password
```

Set up an LI event log

The LI event log provides log events of the LI operations including:

- Logging Events: the time, the date, and the user accessing the LI configuration region

- Configuration Changes Events: every CLI command that is entered in the LI configuration region

- Functional Events: for example, when a subscriber has logged in to the BNG and the LI source becomes active and is actively mirroring to the CC interface

The two methods available to transmit LI log events are SNMP and NETCONF. Nokia recommends to send log events through either SNMP or NETCONF, not both.

Send log events through SNMP

The **system management-interface snmp** function is enabled in the main config region, as follows:

```
!*(pr)[/configure system management-interface snmp]
A:liadmin@latest-BNG2# info detail
    admin-state enable
    packet-size 9216
    streaming {
        admin-state disable
    }
```

The SNMP LI log event server is configured as follows. In this example, the name of the **snmp-trap-group** is "1".

```
!*(pr)[/configure log snmp-trap-group "1"]
A:liadmin@latest-BNG2# info detail
    trap-target "LIG" {
        address 192.168.1.1
        port 162
        version snmpv3
        notify-community "li"
        security-level privacy
        replay false
    }
```

LI is enabled to send LI log events to **snmp-trap-group "1"**. The **log-id "1"** must match the **snmp-trap-group "1"**.

```
A:liadmin@latest-BNG2# info
    li {
        log {
            log-id "1" {
                source {
                    li true
                }
                destination {
                    snmp {
                    }
                }
            }
        }
    }
```

Send log events through NETCONF

To send LI log events through NETCONF, the **system management-interface netconf** function is enabled in the main config region, as follows:

```
[pr:/configure system management-interface netconf]
A:liadmin@latest-BNG2# info
    admin-state enable
```

LI is enabled to send LI log events as NETCONF stream, as follows:

```
!*(pr:li)[/]
```

```
A:liadmin@latest-BNG2# info
    li {
        log {
            log-id "1" {
                netconf-stream "li"
                source {
                    li true
                }
                destination {
                    netconf {
                    }
                }
            }
        }
    }
```

Set up an LI source

An LI source is required to later add specific LI targets.

The LI source requires the mirror destination to already be provisioned. The mirror destination "1" was created by the network administrator in Create a mirror destination for LI use. Depending on the user AAA profile "li", it is possible for the LI administrator to create new mirror destinations. The mirror destination "1" must be referenced in the LI source, as follows:

```
!*(pr:li)[/]
A:liadmin@latest-BNG2# info
    li {
        li-source "1" {
        }
```

Note: When a mirror destination is referenced by an LI source, the mirror destination cannot be removed from the system.

LI events for subscriber management

As depicted in Figure 1: Lawful interception, AAA RADIUS accounting records are transmitted over the INI2 interface. RADIUS accounting is used for subscriber management LI which helps identify the time the subscriber logged on and off. The RADIUS accounting messages can be sent over a AAA accounting server acting as a proxy or the SR OS node can send duplicate accounting records directly to the LIG.

LI target provisioning

The system is now ready to perform LI. LI targets such as SAPs and subscribers can be added to the LI source.

Note: This would typically only be done when a legal warrant is issued in the appropriate jurisdiction.

The following is an example of adding a subscriber target to the LI source:

```
!*(pr:li)[/li li-source "1"]
A:liadmin@latest-BNG2# info
```

```
subscriber "li-source-00" {
    ingress true
    egress true
    intercept-id 1
    session-id 1
}
```

Conclusion

Because the industry is migrating to model driven (MD) management interfaces, Nokia's LI application supports MD-CLI in SR OS Release 19.10.R1 and later. For service providers migrating to MD management interfaces, Nokia's LI application is migration ready and also provides tools to help this migration process. Therefore, operators can be assured of MD migration including the LI features. This chapter also provides guidance for operators that are commissioning new SR OS products using the MD-CLI.

OAM Performance Management Infrastructure

This chapter describes the OAM Performance Management Infrastructure.

Topics in this chapter include:

- Applicability
- Overview
- Configuration
- Conclusion

Applicability

The chapter is initially written for SR OS Release 16.0.R7, but the MD-CLI in the current edition is based on SR OS Release 25.3.R2. This chapter provides information for the configuration of base OAM Performance Management (OAM-PM) components, common to all the supported tests. This chapter does not describe technology-specific test criteria.

Overview

OAM-PM infrastructure provides a common methodology to launch test PDUs that have been purpose-built for delay and loss metrics. The implementation provides a set of transmission, reception, processing, and reporting mechanisms for performance tools supported under the infrastructure. This common infrastructure allows for performance reporting of consistent metrics at the service and network level, regardless of service type (Layer 2 or Layer 3) or transport (Ethernet, IP, or MPLS).

Delay metric results are mapped to counters that represent configured bins, each of which contain a range of results. In addition to the binning function, various delay metrics report minimum, averages, and maximums. Results are reported and mapped for round-trip, forward, and backward measurements. The three key metrics for delay include:

- Frame Delay (FD): Time between applicable timestamps

- InterFrame Delay Variation (IFDV): Difference in delay between adjacent PDUs. This value represents the absolute value of the result.

- Frame Delay Range (FDR): PDU distances from the minimum measured or estimated in that measurement interval

Single-ended loss tools measure both forward and backward directions between peers, representing a unidirectional result. Frame Loss Ratio (FLR) reports the minimum and maximum observed values for the small samples used for loss comparison, and the average covering the overall measurement interval. Reliability metrics comprise availability, unavailability, high-loss intervals (sample slices "delta-t" where loss exceeds the configured threshold), and consecutive high-loss intervals. The reliability metrics are meant to enhance existing availability operational methods that use trouble tickets, alerts, alarms, correlation, and so on, to determine availability. Lost packets that cause recognized unavailability times, including undetermined times, are not included in FLR because they are counted toward unavailability.

Threshold Crossing Alarms (TCAs) can be configured for both delay and loss results, with the possibility to exclude outlying delay values based on the unique requirements of the network.

Results are stored in volatile system memory, written as discrete non-overlapping data sets that align with the configured measurement interval. The results stored in volatile memory may be polled. The completed session results can be recorded to non-volatile memory using accounting policies. These non-volatile results are stored in XML files and can be retrieved using file transfer protocols. The number of measurement intervals stored in non-volatile memory is configurable. The file system and accounting process are mentioned for completeness, but are not the focus of this chapter.

OAM-PM sessions are the basis for configuring and linking all the test-specific information in one location.

Common reporting nomenclature is used regardless of the configured test family. Although technologies may use different terminology, such as packet versus frame, the OAM-PM infrastructure uses single common normalized terms. This commonality simplifies the storage, reporting, collection, and the integration and higher-level analytics. The common approach provides significant operational and management optimization.

Configuration

Most of the configuration elements for the infrastructure components are directly located under the OAM-PM hierarchy. However, there are some linkages to other optional subsystems, such as accounting policies. Figure 3: Configuration tree provides the topics that are included in the configuration section. The "Tech specific (Ethernet, IP, MPLS)" block has been grayed out, because it is not included in this chapter.

Figure 3: Configuration tree
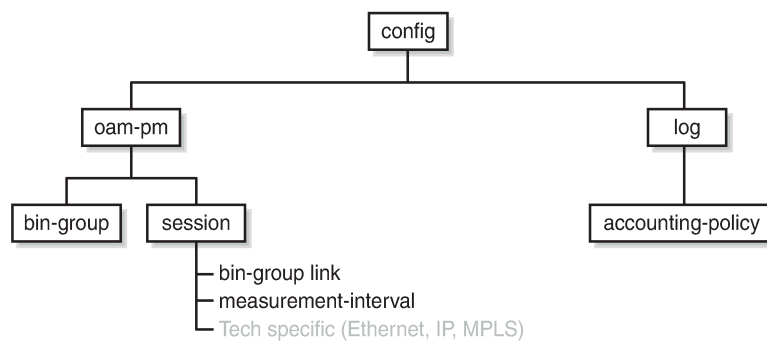
28878

Bin groups

The configurable ranges are based on the unique requirements of the session: delay metrics, direction (round-trip, forward, or backward), measurements of interest, critical measurement markers, network behavior, thresholds of concern, and likely many more operator-specific requirements. Bin groups are only used to store delay metric results.

A bin group can belong to multiple sessions. A session refers to only one bin group.

Per delay metric (FD, IFDV, and FDR), each bin group contains a maximum of ten bins. Higher-numbered bins must have higher ranges than lower-numbered bins. Default ranges for unconfigured bins within the

bin count defaults are 5000 microseconds times the bin number. The range of results stored in the bin is based on the lower bound of that bin and the lower bound of the next higher adjacent bin, with bin 0 having an unchangeable implicit lower bound 0.

Figure 4: Graphical representation of bin group 3 includes shading to demonstrate the importance of the bins. Dark gray shows the results furthest from the objective. These results, although very important to overall reporting and declaration for meeting the objective, should be judged differently than the light gray results. The light gray results are near enough to the objective that adjusting various network options may cause these results to fall into the objective range. The unshaded area of the range represents the objective range. In this case, FDR is only being recorded for interest purposes and has no directives.

Figure 4: Graphical representation of bin group 3
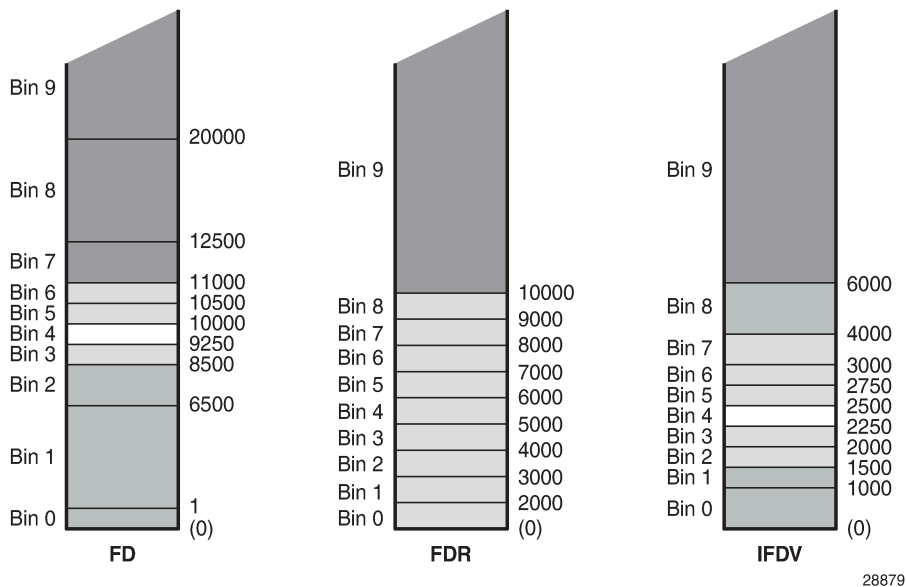
The configuration commands required to create the preceding representation are as follows:

```
configure {
    oam-pm {
        bin-group 3 {
            admin-state enable
            bin-type fd {
                bin 1 {
                    lower-bound 1
                }
                bin 2 {
                    lower-bound 6500
                }
                bin 3 {
                    lower-bound 8500
                }
                bin 4 {
                    lower-bound 9250
                }
                bin 5 {
                    lower-bound 10000
                }
                bin 6 {
                    lower-bound 10500
```

```
            }
            bin 7 {
                lower-bound 11000
            }
            bin 8 {
                lower-bound 12500
            }
            bin 9 {
                lower-bound 20000
            }
        }
        bin-type fdr {
            bin 1 {
                lower-bound 2000
            }
            bin 2 {
                lower-bound 3000
            }
            bin 3 {
                lower-bound 4000
            }
            bin 4 {
                lower-bound 5000
            }
            bin 5 {
                lower-bound 6000
            }
            bin 6 {
                lower-bound 7000
            }
            bin 7 {
                lower-bound 8000
            }
            bin 8 {
                lower-bound 9000
            }
            bin 9 {
                lower-bound 10000
            }
        }
        bin-type ifdv {
            bin 1 {
                lower-bound 1000
            }
            bin 2 {
                lower-bound 1500
            }
            bin 3 {
                lower-bound 2000
            }
            bin 4 {
                lower-bound 2250
            }
            bin 5 {
                lower-bound 2500
            }
            bin 6 {
                lower-bound 2750
            }
            bin 7 {
                lower-bound 3000
            }
            bin 8 {
                lower-bound 4000
```

```
                }
                bin 9 {
                    lower-bound 6000
                }
            }
        }
```

In addition to the basic configuration, three advanced features expand the binning infrastructure:

- Delay TCA (**delay-event**) against a threshold

- Exclude bin counts from the delay TCA (**exclude-lowest-bin**)

- Exclude bins from the computed averages (**exclude-from-avg**)

Individual results are still mapped and accounted for in the appropriate bins. However, excluded results are counted toward the event threshold or included in the rolling average, if explicitly configured to exclude. The following command configures the delay event:

```
configure {
    oam-pm {
        bin-group 3 {
            bin-type fd {
                delay-event {forward|backward|round-trip} {
                    lowest-bin <bin-number>
                    raise-threshold <raise-threshold>
                    clear-threshold <clear-threshold>
```

The delay TCA is per bin type (FD, IFDV, FDR), and requires the direction **{forward | backward | round-trip}**, the **lowest-bin <bin-number>**, the **raise-threshold <raise-threshold>**, and a declaration of stateful [**clear-threshold <clear-threshold>**] or stateless (omission of the **clear-threshold** option).

The **lowest-bin <bin-number>** is the result count including the specified bin and all higher bins. When the total count in that bin and all higher bins equals the configured threshold, the TCA is triggered.

Stateful processing requires a subsequent measurement interval to complete with a count in the specified bin and all higher bins at or below the clear threshold. If the clear threshold option is omitted, the TCA is stateless. Stateless TCA events are not carried over to subsequent measurement intervals. Each measurement interval is unique unto itself. Individual TCAs are raised once at the time of the event during a measurement interval.

The **delay-event-exclusion** allows bins to be removed from the event count. This configuration is per bin type (FD, IFDV, FDR), and requires the direction {**forward|backward|round-trip**} and the **lowest-bin <bin-number>**. The **lowest-bin** excludes the specified bin and all higher bins from the event count.

The following configuration expands **bin-group 3 bin-type fd** to include **delay-event** TCA and a **delay-event-exclusion**. When a test using bin group 3 counts 30 results in bin 7 and 8, it generates a log event indicating that the threshold has been reached. Bin 9 results are not considered against the delay event TCA because of the exclusion statement.

```
configure {
    oam-pm {
        bin-group 3 {
            bin-type fd {
                delay-event round-trip {
                    lowest-bin 7
                    raise-threshold 30
                    clear-threshold 0
                    exclude-lowest-bin 9
                }
```

Some networks include elements with software clocks and possible transmission style equipment that performs circuit establishment on first packet reception. Because these can provide non-representative delay results, these results are typically excluded from the computed averages.

The **exclude-from-avg** configuration is per bin type (FD, IFDV, FDR) and requires the direction (forward, backward, or round-trip) and the bins with their bin numbers. The results in these bins are specifically excluded from the computed average. The bins to be excluded should include the bins that have been configured to track obvious anomalies.

The following configuration further expands **bin-group 3 bin-type fd** to **exclude-from-avg** bins 0 and 9.

```
configure {
    oam-pm {
        bin-group 3 {
            bin-type fd
                exclude-from-avg round-trip {
                    bins "0,9"
```

The complete configuration for bin group 3, including the TCA and exclude configuration, is shown here for completeness.

```
[ex:/configure oam-pm bin-group 3]
A:admin@PE-1# info
    admin-state enable
    bin-type fd {
        delay-event round-trip {
            lowest-bin 7
            raise-threshold 30
            clear-threshold 0
            exclude-lowest-bin 9
        }
        exclude-from-avg round-trip {
            bins "0,9"
        }
        bin 1 {
            lower-bound 1
        }
        bin 2 {
            lower-bound 6500
        }
        bin 3 {
            lower-bound 8500
        }
        bin 4 {
            lower-bound 9250
        }
        bin 5 {
            lower-bound 10000
        }
        bin 6 {
            lower-bound 10500
        }
        bin 7 {
            lower-bound 11000
        }
        bin 8 {
            lower-bound 12500
        }
        bin 9 {
            lower-bound 20000
        }
    }
```

```
        bin-type fdr {
            bin 1 {
                lower-bound 2000
            }
            bin 2 {
                lower-bound 3000
            }
            bin 3 {
                lower-bound 4000
            }
            bin 4 {
                lower-bound 5000
            }
            bin 5 {
                lower-bound 6000
            }
            bin 6 {
                lower-bound 7000
            }
            bin 7 {
                lower-bound 8000
            }
            bin 8 {
                lower-bound 9000
            }
            bin 9 {
                lower-bound 10000
            }
        }
        bin-type ifdv {
            bin 1 {
                lower-bound 1000
            }
            bin 2 {
                lower-bound 1500
            }
            bin 3 {
                lower-bound 2000
            }
            bin 4 {
                lower-bound 2250
            }
            bin 5 {
                lower-bound 2500
            }
            bin 6 {
                lower-bound 2750
            }
            bin 7 {
                lower-bound 3000
            }
            bin 8 {
                lower-bound 4000
            }
            bin 9 {
                lower-bound 6000
            }
        }
```

There are several **show** commands that provide display-level information for bin groups. The power of some of the **show** commands is revealed when tests are mapped to the bin group. Background tests outside the scope of this chapter have been added to enhance the usefulness of this section.

The **show oam-pm bin-group <bin-group-number> detail** command provides information about the configured bin groups.

The base command with no options shows the following bin group information; the description, the admin state, and the ranges for each configured bin type (FD, FDR, IFDV) are displayed.

```
[/]
A:admin@PE-1# show oam-pm bin-group

-------------------------------------------------------------------------------
Configured Lower Bounds for Delay Tests, in microseconds
-------------------------------------------------------------------------------
Group Description                     Admin Bin    FD(us)    FDR(us)   IFDV(us)
-------------------------------------------------------------------------------
1     OAM PM default bin group (not*   Up   0          0          0          0
                                            1       5000       5000       5000
                                            2      10000          -          -
-------------------------------------------------------------------------------
2                                      Up   0          0          0          0
                                            1       1000       1000        500
                                            2       2000       1500        750
                                            3       3000       2000       1000
                                            4       4000       2500       1250
                                            5       5000       3000       1500
                                            6       6000       3500       1750
                                            7       7000       4000       2000
                                            8       8000       4500       2250
                                            9       9000       5000       2500
-------------------------------------------------------------------------------
3                                      Up   0          0          0          0
                                            1          1       2000       1000
                                            2       6500       3000       1500
                                            3       8500       4000       2000
                                            4       9250       5000       2250
                                            5      10000       6000       2500
                                            6      10500       7000       2750
                                            7      11000       8000       3000
                                            8      12500       9000       4000
                                            9      20000      10000       6000
-------------------------------------------------------------------------------
 * indicates that the corresponding row element may have been truncated.
```

To display TCA and exclude information, filter on a single bin-group-number and include the **detail** option, as follows:

```
[/]
A:admin@PE-1# show oam-pm bin-group 3 detail

-------------------------------------------------------------------------------
Configured Lower Bounds for Delay Tests, in microseconds
-------------------------------------------------------------------------------
Group Description                     Admin Bin    FD(us)    FDR(us)   IFDV(us)
-------------------------------------------------------------------------------
3                                      Up   0          0          0          0
                                            1          1       2000       1000
                                            2       6500       3000       1500
                                            3       8500       4000       2000
                                            4       9250       5000       2250
                                            5      10000       6000       2500
                                            6      10500       7000       2750
                                            7      11000       8000       3000
                                            8      12500       9000       4000
```

```
                                           9       20000      10000      6000
        -------------------------------------------------------------------


        ----------------------------------------
        Bins Excluded from Average
        ----------------------------------------
        Bin Type    Direction         Bins
        ----------------------------------------
        FD          round-trip         0,9
        ----------------------------------------


        -------------------------------------------------------------------
        Delay Events Configured
        -------------------------------------------------------------------
        Bin Type    Direction    Lowest Bin    Lower Bound (us)    Raise    Clear
        -------------------------------------------------------------------
        FD          round-trip        7              11000          30       0
        -------------------------------------------------------------------


        ----------------------------------------------------------------
        Bins Excluded from Delay Event Count
        ----------------------------------------------------------------
        Bin Type    Direction     Lowest Excluded Bin    Lower Bound (us)
        ----------------------------------------------------------------
        FD          round-trip              9                  20000
        ----------------------------------------------------------------
```

The **show oam-pm bin-group-using [bin-group <bin-group-number>]** command shows a mapping of
sessions to bin groups. The base command shows all mappings, as follows. Adding the optional **bin-group
<bin-group-number>** command limits the output to the specified bin group.

```
[/]
A:admin@PE-1# show oam-pm bin-group-using

===========================================================================
OAM Performance Monitoring Bin Group Configuration for Sessions
===========================================================================
Bin Group      Admin   Session                           Session State
---------------------------------------------------------------------------
1              Up      ip-rtr-telemetry-streaming              Act
---------------------------------------------------------------------------
2              Up      mpls-dm-rsvp-PE-2-PE-1                   Act
                       mpls-dm-static-PE-2-PE-1                 Act
                       mpls-dm-rsvp-PE-2-PE-1-hop1             Act
                       mpls-dm-rsvp-auto-PE-2-PE-1             Act
                       mpls-dm-static-PE-2-PE-1-hop1           Act
---------------------------------------------------------------------------
3              Up      ip-lpb101-RSVP-LSP                      Act
                       ip-lpb111-SR-TE-LSP                     Act
                       ip-rtr-int-PE-1-PE-2                     Act
                       eth-port-int-PE-2-P-3                    Act
                       ip-circuit-service-vprn2                Act
                       eth-circuit-service-vpls3               Act
                       eth-circuit-service-epipe1              Act
                       eth-circuit-service-epipe1-2            Act
                       eth-circuit-service-epipe1-3            Act
---------------------------------------------------------------------------
===========================================================================
```

In summary, the bin group contains three configurable bin types: FD, IFDV, and FDR. Results are mapped
to the counter in the appropriate bin, considering any configured TCA or event exclusions. The various

delay metric average computations can be influenced by an optional configuration that excludes specific results from the calculation.

Session

The session is the container bringing the individual testing elements together. The **session <session-name>** identifies the collection as one comprehensive entity. The test family choice **<ethernet|ip|mpls>** defines the type of technology test that can be configured within that session and enforces various technology-specific configuration rules. The rules ensure that only technology relevant to the configuration parameter matching the test family can be configured.

```
*[ex:/configure oam-pm session "test"]
A:admin@PE-1# ?

 Immutable fields     - session-type

 apply-groups         - Apply a configuration group at this level
 apply-groups-exclude - Exclude a configuration group at this level
 bin-group            - Bin group for the session
 description          - Text description
 measurement-interval + Enter the measurement-interval list instance
 session-type         - Session type

 Mandatory choice: test-family-choice
 ethernet             :+ Enable the ethernet context
 ip                   :+ Enable the ip context
 mpls                 :+ Enable the mpls context
```

The **session-type {proactive|on-demand}** (as follows) defines whether the session is always on, proactive, or must be started manually using the **oam oam-pm session <session-name> test-type {dm| dmm|lmm|slm|twamp-light} action {start|stop}** command, on demand.

```
*[ex:/configure oam-pm session "test"]
A:admin@PE-1# session-type ?

 session-type <keyword>
 <keyword> - (proactive|on-demand)
 Default   - proactive

 'session-type' is: immutable

    Session type

    Warning: Modifying this element recreates 'configure oam-pm session "test"'
             automatically for the new value to take effect.
```

A bin group can be assigned to the session. If no bin group is specified, the default bin group **bin-group 1** is used. A session can support multiple different tests from the same test family. If the test being configured is a loss only test, there is no need to add a bin group to the session. Loss tests do not use bin groups. The following configuration defines a session "*ip-rtr-int-PE-1-PE-2*" with session type proactive, bin group 3, and test family IP:

```
configure {
    oam-pm {
        session "ip-rtr-int-PE-1-PE-2" {
            session-type proactive
            bin-group 3
```

```
            ip {
            ---snip---          # technology-specific test parameters are outside the scope
            }
```

A description can be added to the session to provide more administrative information, as follows:

```
configure {
    oam-pm {
        session "ip-rtr-int-PE-1-PE-2" {
            description "ip circuit connecting PE-1 to PE-2"
```

The final step before configuring the technology-specific test parameters within the session is defining the size of the sample window: the measurement interval. Each session requires at least one measurement interval to be assigned. There are five fixed-size measurement intervals, typical for service level agreement: **measurement-interval {15-mins|1-hour|1-day|5-mins|1-min}**.

It is possible to assign more than one measurement interval to a session. Each measurement interval is updated independently and maintains its own statistics and memory allocation. Nokia recommends that only a single measurement interval be configured per session to avoid unnecessary processing and memory consumption. The value of configuring multiple measurement intervals is negligible. Higher-level systems can perform the necessary analytics and data merges.

The *raw* measurement interval is an always-on, never-ending collection of samples since the start or last clearing of the *raw* measurement interval. If the operator does not configure a measurement interval within the session, the *raw* measurement interval is the only one applied. An example of configuring the measurement interval is as follows:

```
configure {
    oam-pm {
        session "ip-rtr-int-PE-1-PE-2" {
            measurement-interval 5-mins {
```

The results are stored in volatile system memory, written as discrete non-overlapping datasets that align with the measurement interval time configuration.

> **Note:**
> The following does not apply to the *raw* measurement interval. This measurement interval has no configuration options and is only stored in non-volatile memory. Its intent is for troubleshooting, not SLA measurement.

The number of stored completed datasets in non-volatile memory is configurable. The results stored in volatile memory are available through polling tools. Optionally, but highly recommended, the completed session results can be written to the file system. The file system and accounting process are not the focus of this chapter. However, the following basic context is provided for completeness.

Accounting policies are defined as part of the logging function. The location defines where to store the file. The collection interval defines how often the process collects the completed records. The record type indicates the types of records to be collected, in the case of OAM-PM complete-pm is required. The rollover defines when the file is closed. The retention defines how long the closed file is kept.

This chapter provides the following basic sample configuration with mandatory requirements to write the appropriate OAM-PM record and maintain the file.

```
configure {
    log {
        file "19" {
            description "oam-pm file maintenance options id 19"
```

```
                rollover 30
                retention 2
                compact-flash-location {
                    primary cf3
                }
            }
        accounting-policy 9 {
            admin-state enable
            description "oam-pm accounting policy 19"
            collection-interval 10
            record complete-pm
            destination {
                file "19"
            }
        }
```

After the accounting policy is configured, the session can use that configuration, as follows:

```
configure {
    oam-pm {
        session "ip-rtr-int-PE-1-PE-2" {
            description "ip circuit connecting PE-1 to PE-2"
            session-type proactive
            bin-group 3
            ip {
---snip---        # technology-specific test parameters outside the scope of the chapter
            }
            measurement-interval 5-mins {
                accounting-policy 9
            }
```

The amount of system memory consumed by intervals stored in volatile memory can be reduced if write to file is the selected collection method. It is then possible to reduce the number of intervals stored because the reliance on data collection routines from volatile memory is reduced. The data is available from the non-volatile files system and remains for the **interval-stored <intervals> count**.

When the allocation reaches the maximum configured value, the oldest dataset is removed to make room for the newest. Nokia suggests using accounting policy to reduce the intervals stored when writing results to the XML file, balancing the requirements of the environment. The following configuration shows that 24 five-minute measurement intervals are stored in volatile memory.

```
configure {
    oam-pm {
        session "ip-rtr-int-PE-1-PE-2" {
            description "ip circuit connecting PE-1 to PE-2"
            session-type proactive
            bin-group 3
            ip {
---snip---
            }
            measurement-interval 5-mins {
                accounting-policy 9
                intervals-stored 24
            }
```

The alignment of the measurement interval to the timing reference is determined by the **boundary-type {clock-aligned | test-relative}**. Tests start based on their operational state: enabled for proactive, or **oam oam-pm session <session-name> test-type {dm|dmm|lmm|slm|twamp-light} action start** for on-demand. Clock-aligned measurement intervals align to wall clock time (time of day), starting and stopping on that specific time. For example, a five-minute measurement interval that is clock aligned stops on

every five-minute clock occurrence: 5, 10, 15, 20, 25, 30, and so on. A test-relative alignment means that the measurement interval time starts when the test becomes operational, and runs for the length of that interval. For example, if a test becomes operational at two minutes after the hour, the five-minute measurement intervals stops at 7, 12, 17, 22, 27, 32, and so on.

Clock-aligned measurement intervals are typical for proactive sessions. Test-aligned measurement intervals are typically used for on demand sessions. The default **boundary-type** is shown in the following output.

```
configure {
    oam-pm {
        session "ip-rtr-int-PE-1-PE-2" {
            description "ip circuit connecting PE-1 to PE-2"
            session-type proactive
            bin-group 3
            ip {
---snip---
            }
            measurement-interval 5-mins {
                accounting-policy 9
                boundary-type clock-aligned      # default value
                intervals-stored 24
            }
```

The first completed clock-aligned measurement interval typically has the suspect flag set, if it started ten or more seconds after a normally scheduled measurement interval. The suspect flag is also set if a test is stopped ten or more seconds before the end of the regular measurement interval.

The clock-offset option allows for a divergence to be configured from the natural clock starting time. The option provides a method to stagger the measurement interval start with a number of seconds, using the following command:

```
[ex:/configure oam-pm session "ip-rtr-int-PE-1-PE-2" measurement-interval 5-mins]
A:admin@PE-1# clock-offset ?

 clock-offset <number>
 <number> - <0..86399> - seconds
 Default  - 0

    Offset for a clock-aligned measurement interval
```

A session allows one of its configured measurement intervals to monitor configured TCA events. Delay events are configured under the bin group and were described earlier. Loss events are configured under the technology-specific test type and not part of this chapter.

Event monitoring reporting can be modified while the bin group is enabled. On modification, existing events and the ability to compute new TCAs wait for the start of a subsequent measurement interval when changes are made during an active measurement interval. If the modification is made in near proximity to the completion of one measurement interval, the introduction of the new TCA may require a further measurement interval to implement the change and restart the TCA computations.

The following configuration example shows that event monitoring is enabled for **delay-events** and disabled for **loss-events**, under the **measurement-interval 5-min**.

```
configure {
    oam-pm {
        session "ip-rtr-int-PE-1-PE-2" {
            description "ip circuit connecting PE-1 to PE-2"
            bin-group 3
```

```
            ip {
---snip---         # technology-specific parameters are outside the scope of the chapter
            }
            measurement-interval 5-mins {
                accounting-policy 9
                boundary-type clock-aligned     # default value
                clock-offset 0                  # default value
                intervals-stored 24
                threshold-cross-alerts {        # event monitoring
                    admin-state enable
                    delay-events true
                    loss-events false           # default value
                }
            }
        }
```

The infrastructure OAM-PM components are now configured.

The test family attributes are technology-specific parameters that define the test parameters and influence the PDUs. This test-specific configuration is stored under the technology type: IP, Ethernet, or MPLS. Usually, the configuration parameters under this hierarchy include quality of service (QoS), source and destination, interval, padding, transport-specific parameters, and the type of test packet to be transmitted and processed. Technology-specific configurations are outside the scope of this chapter, which is specific to the OAM-PM infrastructure.

There are several **show** commands that provide display-level information for sessions. The power of some of the **show** commands are revealed when complete session configurations with technology-specific tests are available. Background tests outside the scope of this chapter have been added to enhance the usefulness of this section.

The command **show oam-pm sessions [test-family {ethernet|ip|mpls}] [detectable-tx-errors|event-mon]** provides information about the sessions that are configured.

The base command with no options shows the following session information sorted by test family: session name, admin state, mapped bin group, session type, and test types configured under the session. When the **test-family** option is included, the output is limited to that family.

```
[/]
A:admin@PE-1# show oam-pm sessions

===============================================================================
OAM Performance Monitoring Session Summary for the Ethernet Test Family
===============================================================================
Session                       State   Bin Group   Sess Type   Test Types
-------------------------------------------------------------------------------
eth-port-int-PE-2-P-3         Act           3     proactive   DMM
eth-circuit-service-vpls3     Act           3     proactive   DMM     SLM
eth-circuit-service-epipe1    Act           3     proactive   DMM LMM SLM
eth-circuit-service-epipe1-2  Act           3     proactive   DMM     SLM
eth-circuit-service-epipe1-3  Act           3     proactive   DMM     SLM
===============================================================================


===============================================================================
OAM Performance Monitoring Session Summary for the IP Test Family
===============================================================================
Session                       State   Bin Group   Sess Type   Test Types
-------------------------------------------------------------------------------
ip-lpb101-RSVP-LSP            Act           3     proactive           TWL
ip-lpb111-SR-TE-LSP           Act           3     proactive           TWL
ip-rtr-int-PE-1-PE-2          Act           3     proactive           TWL
ip-circuit-service-vprn2      Act           3     proactive           TWL
ip-rtr-telemetry-streaming    Act           1     proactive           TWL
```

```
================================================================

================================================================
OAM Performance Monitoring Session Summary for the MPLS Test Family
================================================================
Session                        State   Bin Group   Sess Type   Test Types
----------------------------------------------------------------
mpls-dm-rsvp-PE-2-PE-1          Act         2       proactive          DM
mpls-dm-static-PE-2-PE-1        Act         2       proactive          DM
mpls-dm-rsvp-PE-2-PE-1-hop1     Act         2       proactive          DM
mpls-dm-rsvp-auto-PE-2-PE-1     Act         2       proactive          DM
mpls-dm-static-PE-2-PE-1-hop1   Act         2       proactive          DM
================================================================
```

To display all sessions with detected transmission errors that prevent the transmission of test PDUs, the **detectable-tx-errors** filter can be added. The following output shows the Ethernet session *eth-cfm-31-28-rtr1* with a detectable error "MEP not fully configured or admin down".

```
[/]
A:admin@PE-1# show oam-pm sessions detectable-tx-errors

================================================================
OAM Performance Monitoring Transmit Error Summary: Ethernet Test Family
================================================================
                          Test
Session                   Type            Detectable Transmit Error
----------------------------------------------------------------
eth-cfm-31-28-rtr1        DMM    MEP not fully configured or admin down
================================================================


================================================================
OAM Performance Monitoring Transmit Error Summary: IP Test Family
================================================================
                          Test
Session                   Type            Detectable Transmit Error
----------------------------------------------------------------
================================================================


================================================================
OAM Performance Monitoring Transmit Error Summary: MPLS Test Family
================================================================
                          Test
Session                   Type            Detectable Transmit Error
----------------------------------------------------------------
================================================================
```

To display the event monitoring configuration of all sessions, the **event-mon** filter can be added. The following output shows all the sessions and any related event monitoring configuration and state of the event.

```
[/]
A:admin@PE-1# show oam-pm sessions event-mon

================================================================
OAM Performance Monitoring Event Summary for the Ethernet Test Family
================================================================
Event Monitoring Table Legend:
F = Forward,  B = Backward,  R = Round Trip,  A = Aggregate,
- = Threshold Not Config,  c = Threshold Config,  * = TCA Active,  P = Pending
================================================================
                          Test    FD FDR IFDV FLR CHLI HLI UNAV UDAV UDUN
Session                   Type    FBR FBR  FBR  FB  FBA FBA  FBA  FBA  FBA
```

```
--------------------------------------------------------------------------
eth-port-int-PE-2-P-3           DMM  --c --- ---
eth-circuit-service-vpls3       DMM  --c --- ---
eth-circuit-service-vpls3       SLM            --  --- --- --- --- ---
eth-circuit-service-epipe1      DMM  --c --- ---
eth-circuit-service-epipe1      LMM            --  --- --- --- --- ---
eth-circuit-service-epipe1      SLM            --  --- --- --- --- ---
eth-circuit-service-epipe1-2    DMM  --c --- ---
eth-circuit-service-epipe1-2    SLM            --  --- --- --- --- ---
eth-circuit-service-epipe1-3    DMM  --c --- ---
eth-circuit-service-epipe1-3    SLM            --  --- --- --- --- ---
==========================================================================


==========================================================================
OAM Performance Monitoring Event Summary for the IP Test Family
==========================================================================
Event Monitoring Table Legend:
F = Forward,  B = Backward,  R = Round Trip,  A = Aggregate,
- = Threshold Not Config,  c = Threshold Config,  * = TCA Active,  P = Pending
==========================================================================
                             Test   FD FDR IFDV FLR CHLI HLI UNAV UDAV UDUN
Session                      Type   FBR FBR  FBR  FB  FBA FBA  FBA  FBA  FBA
--------------------------------------------------------------------------
ip-lpb101-RSVP-LSP                  TWL  --c --- ---  --  --- ---  ---  ---  ---
ip-lpb111-SR-TE-LSP                 TWL  --c --- ---  --  --- ---  ---  ---  ---
ip-rtr-int-PE-1-PE-2                TWL  --c --- ---  --  --- ---  ---  ---  ---
ip-circuit-service-vprn2            TWL  --c --- ---  --  --- ---  ---  ---  ---
ip-rtr-telemetry-streaming          TWL  --- --- ---  --  --- ---  ---  ---  ---
==========================================================================


==========================================================================
OAM Performance Monitoring Event Summary for the MPLS Test Family
==========================================================================
Event Monitoring Table Legend:
F = Forward,  B = Backward,  R = Round Trip,  A = Aggregate,
- = Threshold Not Config,  c = Threshold Config,  * = TCA Active,  P = Pending
==========================================================================
                             Test   FD FDR IFDV FLR CHLI HLI UNAV UDAV UDUN
Session                      Type   FBR FBR  FBR  FB  FBA FBA  FBA  FBA  FBA
--------------------------------------------------------------------------
mpls-dm-rsvp-PE-2-PE-1              DM   --c --- ---
mpls-dm-static-PE-2-PE-1           DM   --c --- ---
mpls-dm-rsvp-PE-2-PE-1-hop1        DM   --c --- ---
mpls-dm-rsvp-auto-PE-2-PE-1        DM   --c --- ---
mpls-dm-static-PE-2-PE-1-hop1      DM   --c --- ---
==========================================================================
```

The command **show oam-pm session <session-name> [all|base|bin-group|event-mon|meas-interval]** provides information about an individual session.

The base command with no options, which defaults to **all**, shows the configuration for the session, technology-specific parameters, the test, the measurement interval specifics, the bin group specifics and event information. The optional filters **[all|base|bin-group|event-mon|meas-interval]** are used to limit the output to a specific section of the overall output.

```
[/]
A:admin@PE-1# show oam-pm session "ip-rtr-int-PE-1-PE-2"


--------------------------------------------------------------------------
Basic Session Configuration
--------------------------------------------------------------------------
Session Name      : ip-rtr-int-PE-1-PE-2
Description       : ip circuit connecting PE-1 to PE-2
```

```
Test Family      : ip                Session Type      : proactive
Bin Group        : 3
-------------------------------------------------------------------------

-------------------------------------------------------------------------
IP Configuration
-------------------------------------------------------------------------
Source IP Address : 192.0.2.1
Dest IP Address   : 192.0.2.2
Confg Src UDP Port: (Not Specified)    In-Use Src UDP Port: 49154
Dest UDP Port     : 862               Time To Live      : 255
Forwarding Class  : be                Profile           : out
DSCP              : resolve           Allow Remark DSCP : no
Router            : (Not Specified)   Bypass Routing    : no
Egress Interface  : (Not Specified)
Next Hop Address  : (Not Specified)
Do Not Fragment   : no                Pattern           : 0
Router Instnce:Base
Tunnel Type       : none
-------------------------------------------------------------------------

-------------------------------------------------------------------------
TWAMP-Light Test Configuration and Status    Session Sender Type : TWAMP-Light
-------------------------------------------------------------------------
Test ID           : 2147483648(auto)  Admin State       : Up
Oper State        : Up                Pad Size          : 0 octets
Pad TLV Size      : Not Applicable    Timestamp Format  : NTP
On-Demand Duration: Not Applicable    On-Demand Remaining: Not Applicable
Interval          : 100 ms            Record Stats      : delay-and-loss
CHLI Threshold    : 5 HLIs            Frames Per Delta-T : 1 frames
Consec Delta-Ts   : 10                FLR Threshold     : 50%
HLI Force Count   : no                IPv6 UDP Checksum 0: Disallow
Detectable Tx Err : none
Session Sender ID : Not Applicable
STAMP U Flags Rx  : Not Applicable    STAMP M Flags Rx   : Not Applicable
Str Delay Tmpl:(Not Specified)
-------------------------------------------------------------------------

-------------------------------------------------------------------------
5-mins Measurement Interval Configuration
-------------------------------------------------------------------------
Duration          : 5-mins            Intervals Stored  : 24
Boundary Type     : clock-aligned     Clock Offset      : 0 seconds
Accounting Policy : 9                 Event Monitoring  : enabled
Delay Event Mon   : enabled           Loss Event Mon    : disabled
-------------------------------------------------------------------------

-------------------------------------------------------------------------
Configured Lower Bounds for Delay Tests, in microseconds
-------------------------------------------------------------------------
Group Description                 Admin Bin    FD(us)    FDR(us)   IFDV(us)
-------------------------------------------------------------------------
3                                 Up   0         0          0          0
                                       1         1       2000       1000
                                       2      6500       3000       1500
                                       3      8500       4000       2000
                                       4      9250       5000       2250
                                       5     10000       6000       2500
                                       6     10500       7000       2750
                                       7     11000       8000       3000
                                       8     12500       9000       4000
                                       9     20000      10000       6000
-------------------------------------------------------------------------
```

```
----------------------------------------
Bins Excluded from Average
----------------------------------------
Bin Type     Direction          Bins
----------------------------------------
FD           round-trip         0,9
----------------------------------------


-----------------------------------------------------------------
Bins Excluded from Delay Event Count
-----------------------------------------------------------------
Bin Type     Direction     Lowest Excluded Bin     Lower Bound (us)
-----------------------------------------------------------------
FD           round-trip                   9                  20000
-----------------------------------------------------------------


------------------------------------------------------------------------
Delay Events for the TWAMP-Light Test
------------------------------------------------------------------------
Bin Type    Direction    LowerBound(us)    Raise    Clear        Last TCA (UTC)
------------------------------------------------------------------------
FD          round-trip           11000       30       0                   none
------------------------------------------------------------------------


------------------------------------------------------------------------
Loss Events for the TWAMP-Light Test
------------------------------------------------------------------------
Event Type              Direction      Raise     Clear       Last TCA (UTC)
------------------------------------------------------------------------
------------------------------------------------------------------------
```

The stored information in the volatile memory, **intervals-stored**, can be displayed using the **show oam-pm statistics session <session-name> <dm|dmm|lmm|slm|twamp-light> meas-interval {raw|{5-mins|15-mins|1-hour|1-day} interval-number <interval-number> [loss | delay]** command. The interval is with reference to the latest session data. The **interval-number 1** is current, and previously completed results are incremented from 1, representing their position to current. The **[loss|delay]** options can only be used for tests that include both loss and delay as part of the PDU; for example, twamp-light. The **interval-number** is not required when the **meas-interval raw** is the selected option; there is only one.

```
[/]
A:admin@PE-1# show oam-pm statistics session "ip-rtr-int-PE-1-PE-2" twamp-light meas-interval
 5-mins interval-number 2


-----------------------------------------------------------------------
Start (UTC)      : 2025/05/14 07:04:11       Status       : completed
Elapsed (seconds) : 300                      Suspect      : no
Frames Sent      : 3000                      Frames Received : 3000
-----------------------------------------------------------------------
=======================================================================
TWAMP-LIGHT DELAY STATISTICS


-----------------------------------------------------------------------
Bin Type     Direction     Minimum (us)   Maximum (us)   Average (us)   EfA
-----------------------------------------------------------------------
FD           Forward               205            899            440    no
FD           Backward               84            868            263    no
FD           Round Trip            457           1516            704    yes
FDR          Forward                 0            687            233    no
FDR          Backward                0            784            179    no
FDR          Round Trip              0           1050            242    no
IFDV         Forward                 0            537             73    no
IFDV         Backward                0            639             68    no
```

```
IFDV          Round Trip                0          680          108    no
-----------------------------------------------------------------------
EfA = yes: one or more bins configured to be Excluded from the Average calc.


----------------------------------------------------------------
Frame Delay (FD) Bin Counts
----------------------------------------------------------------
Bin     Lower Bound      Forward     Backward     Round Trip
----------------------------------------------------------------
0              0 us           0            0             0
1              1 us        3000         3000          3000
2           6500 us           0            0             0
3           8500 us           0            0             0
4           9250 us           0            0             0
5          10000 us           0            0             0
6          10500 us           0            0             0
7          11000 us           0            0             0
8          12500 us           0            0             0
9          20000 us           0            0             0
----------------------------------------------------------------


----------------------------------------------------------------
Frame Delay Range (FDR) Bin Counts
----------------------------------------------------------------
Bin     Lower Bound      Forward     Backward     Round Trip
----------------------------------------------------------------
0              0 us        3000         3000          3000
1           2000 us           0            0             0
2           3000 us           0            0             0
3           4000 us           0            0             0
4           5000 us           0            0             0
5           6000 us           0            0             0
6           7000 us           0            0             0
7           8000 us           0            0             0
8           9000 us           0            0             0
9          10000 us           0            0             0
----------------------------------------------------------------


----------------------------------------------------------------
Inter-Frame Delay Variation (IFDV) Bin Counts
----------------------------------------------------------------
Bin     Lower Bound      Forward     Backward     Round Trip
----------------------------------------------------------------
0              0 us        3000         3000          3000
1           1000 us           0            0             0
2           1500 us           0            0             0
3           2000 us           0            0             0
4           2250 us           0            0             0
5           2500 us           0            0             0
6           2750 us           0            0             0
7           3000 us           0            0             0
8           4000 us           0            0             0
9           6000 us           0            0             0
----------------------------------------------------------------
================================================================================
================================================================================
TWAMP-LIGHT LOSS STATISTICS


----------------------------------------------------------------
                    Frames Sent      Frames Received
----------------------------------------------------------------
Forward                 3000                 3000
Backward                3000                 3000
----------------------------------------------------------------
```

```
-----------------------------------------------
Frame Loss Ratios
-----------------------------------------------
            Minimum     Maximum     Average
-----------------------------------------------
Forward       0.000%      0.000%      0.000%
Backward      0.000%      0.000%      0.000%
-----------------------------------------------


--------------------------------------------------------------------------
Availability Counters (Und = Undetermined)
--------------------------------------------------------------------------
            Available   Und-Avail Unavailable Und-Unavail      HLI      CHLI
--------------------------------------------------------------------------
Forward        3000           0           0           0         0         0
Backward       3000           0           0           0         0         0
--------------------------------------------------------------------------
==========================================================================
```

The **meas-interval raw** clear and statistics are as follows. It is the only measurement interval that may be cleared.

```
[/]
A:admin@PE-1# clear oam-pm session "ip-rtr-int-PE-1-PE-2" twamp-light

[/]
A:admin@PE-1# show oam-pm statistics session "ip-rtr-int-PE-1-PE-2" twamp-light meas-interval
 raw
-----------------------------------------------------------------------------
Start (UTC)      : 2025/05/14 07:08:01       Status         : in-progress
Elapsed (seconds) : 24                        Suspect        : yes
Frames Sent      : 241                       Frames Received : 241
-----------------------------------------------------------------------------
=============================================================================
TWAMP-LIGHT DELAY STATISTICS

-----------------------------------------------------------------------------
Bin Type    Direction    Minimum (us)  Maximum (us)  Average (us)   EfA
-----------------------------------------------------------------------------
FD          Forward              274           578           402    no
FD          Backward             147           571           260    no
FD          Round Trip           475           998           662    yes
FDR         Forward                0           304           117    no
FDR         Backward               0           424           112    no
FDR         Round Trip             0           516           178    no
IFDV        Forward                0           247            64    no
IFDV        Backward               0           334            61    no
IFDV        Round Trip             2           409           103    no
-----------------------------------------------------------------------------
EfA = yes: one or more bins configured to be Excluded from the Average calc.


---------------------------------------------------------------
Frame Delay (FD) Bin Counts
---------------------------------------------------------------
Bin      Lower Bound       Forward      Backward      Round Trip
---------------------------------------------------------------
0              0 us              0             0               0
1              1 us            254           254             254
2           6500 us              0             0               0
3           8500 us              0             0               0
4           9250 us              0             0               0
5          10000 us              0             0               0
```

```
6             10500 us             0              0              0
7             11000 us             0              0              0
8             12500 us             0              0              0
9             20000 us             0              0              0
-------------------------------------------------------------------

-------------------------------------------------------------------
Frame Delay Range (FDR) Bin Counts
-------------------------------------------------------------------
Bin     Lower Bound      Forward      Backward     Round Trip
-------------------------------------------------------------------
0              0 us           262          262          262
1           2000 us             0            0            0
2           3000 us             0            0            0
3           4000 us             0            0            0
4           5000 us             0            0            0
5           6000 us             0            0            0
6           7000 us             0            0            0
7           8000 us             0            0            0
8           9000 us             0            0            0
9          10000 us             0            0            0
-------------------------------------------------------------------

-------------------------------------------------------------------
Inter-Frame Delay Variation (IFDV) Bin Counts
-------------------------------------------------------------------
Bin     Lower Bound      Forward      Backward     Round Trip
-------------------------------------------------------------------
0              0 us           261          261          261
1           1000 us             0            0            0
2           1500 us             0            0            0
3           2000 us             0            0            0
4           2250 us             0            0            0
5           2500 us             0            0            0
6           2750 us             0            0            0
7           3000 us             0            0            0
8           4000 us             0            0            0
9           6000 us             0            0            0
-------------------------------------------------------------------
===================================================================
===================================================================
TWAMP-LIGHT LOSS STATISTICS

-----------------------------------------------------------
                  Frames Sent       Frames Received
-----------------------------------------------------------
Forward               266                   266
Backward              266                   266
-----------------------------------------------------------

-----------------------------------------------
Frame Loss Ratios
-----------------------------------------------
          Minimum     Maximum     Average
-----------------------------------------------
Forward      0.000%      0.000%      0.000%
Backward     0.000%      0.000%      0.000%
-----------------------------------------------

--------------------------------------------------------------------
Availability Counters (Und = Undetermined)
--------------------------------------------------------------------
          Available   Und-Avail Unavailable Und-Unavail     HLI     CHLI
--------------------------------------------------------------------
```

```
Forward          266            0            0            0            0            0
Backward         266            0            0            0            0            0
-----------------------------------------------------------------------------
=============================================================================
```

Conclusion

OAM-PM is a powerful performance management function. It uses a common architecture to configure, process, and report on technology-specific performance management tools for Ethernet, IP, and MPLS.

Customer document and product support

Customer documentation
Customer documentation welcome page

Technical support
Product support portal

Documentation feedback
Customer documentation feedback