Junos OS

Junos Telemetry User Guide

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Junos OS Junos Telemetry User Guide
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About This Guide

Junos Telemetry enables you to stream device data from Juniper devices to external data collectors. This data can include information about traffic patterns, device status, error rates, and other metrics that provide insights into the network's health and behavior. Telemetry data is streamed over gRPC connections, and the connections can be initiated from a Juniper device or an external data collector.

Use this guide to understand the concepts and features of Junos Telemetry, design your telemetry solution, and configure the streaming of device information to data collectors.

1

PART

Junos Telemetry

Understanding Junos Telemetry

SUMMARY

Junos Telemetry is a framework developed by Juniper Networks that enables the export of operational data from Junos devices to external collectors. This data is analyzed for real-time device monitoring. This topic describes the concepts of model-driven telemetry, telemetry modes, transport protocols, telemetry sensors, sensor paths, and data models used by Junos Telemetry.

IN THIS SECTION

Network Telemetry

Network telemetry is the process of collecting, transmitting, and analyzing data from network devices. This data can include information about traffic patterns, device status, error rates, and other metrics that provide insights into the health and behavior of the network. Using this data, you can draw useful insights and apply this information to monitor and manage network performance and security effectively. Network administrators can use telemetry data to troubleshoot network issues, detect anomalies, and optimize resource utilization across the network. One of the key benefits of network telemetry is its ability to provide real-time visibility into network operations.

Network telemetry also plays a crucial role in enhancing network security. By analyzing telemetry data, security teams can identify unusual patterns that may indicate a cyber-attack or other security threats, thus enabling faster detection and response to potential security incidents and helping to protect the network and its data.

Junos Telemetry

Junos Telemetry is Juniper's telemetry solution, developed to stream telemetry data. It is highly scalable and can support monitoring devices remotely in a network. It also helps improve troubleshooting, proactively manage the network, and reduce operational costs.

Junos Telemetry can be applied in a variety of network scenarios:

- **Performance monitoring:** Monitor key metrics like interface utilization, latency, and packet loss to ensure optimal network performance.
- **Security monitoring:** Track security events, analyze traffic patterns, and identify potential security threats.
- **Application performance management:** Gain insights into application performance by correlating network data with application data.
- **Network capacity planning:** Analyze historical and real-time data to identify potential bottlenecks and plan for future capacity needs.

Other Juniper applications also utilize Junos Telemetry to provide real-time data, supporting operational state synchronization between network elements and an external controller, such as Juniper's Mist, Juniper's Routing Director, and Apstra.

Model-Driven Telemetry

Junos Telemetry has adopted a Model Driven Telemetry (MDT) architecture. A model-driven network telemetry system is an advanced approach to network monitoring that leverages data models to define and collect telemetry data from network devices. In this system, data models are defined using a YANG (Yet Another Next Generation) language to specify the structure and types of data to be collected or streamed.

Juniper currently supports two different data models:

- Juniper Native data model
- OpenConfig data model

Both models use YANG to specify the data structure and data types to be streamed, for more information, see "Data Models" on page 8.

Choosing the right data model depends on the specific needs. You can subscribe to sensors from both OpenConfig and native models simultaneously.

Follow the steps below to set up a model-driven telemetry solution:

1. **Set up the Juniper device to stream telemetry data:** Ensure that the Juniper device runs a compatible Junos OS version that supports Junos Telemetry and the network connectivity between the Juniper device and the collector is present.

2. **Set up the data collector**: Configure the collector to collect and decode the data. For more information, see "Telemetry Data Collector" on page 5.

3. **Establish the transport protocols**: Choose and configure the appropriate transport protocols for data transmission. For more information, see "Telemetry Protocols" on page 7.

4. **Configure the sensor**: A sensor profile defines the parameters of the system resource to be monitored and streamed. You can enable only one system resource to monitor each sensor profile or configure a different sensor profile for each system resource. You can, however, configure more than one sensor to monitor the same system resource. For more information, see "Sensors and Sensor Paths" on page 4.

5. **Create subscriptions**: Set up subscriptions for the data streams you need to monitor. The telemetry session can be established in dial-in mode or dial-out mode, depending on whether the device or receiver is configured to initiate the subscription. For more information, see "Telemetry Modes" on page 5.

Sensors and Sensor Paths

Telemetry sensors are an important component of a telemetry solution. They measure various physical, environmental, and performance parameters and convert them into data that is transmitted over TCP or UDP connections to the collector for remote monitoring and analysis. Some examples are temperature sensors, interface sensors, flow sensors, and so on. A telemetry sensor path is a specific route within a data model, defined using YANG, that specifies the exact data to be collected and streamed from a network device. Juniper supports sensors from both Openconfig and native models. Openconfig sensors track counter-based or state-based metrics and native sensors effectively track event-driven metrics as these sensors have access to in-depth device data. You can configure Openconfig-based sensors paths to retrieve sensor information in a vendor-neutral format or configure native sensor paths to retrieve

Juniper proprietary information in a native format. For more information see, "Explore Sensor Paths" on page 9.

Telemetry Data Collector

The telemetry collector is a specialized tool or software that performs data collection, processing, transmission, and storage of telemetry data. It is an intermediary between the Junos devices generating telemetry data and the backend systems that store, analyse, and visualize it.

Functions of a data collector:

- Data Collection: The collector receives telemetry data from Juniper devices over gRPC or UDP connections.
- Data Processing: The collector processes the collected data by aggregating and normalizing it to filter out unnecessary information, aggregate metrics, and perform an initial analysis. This processing helps reduce the data volume and focus on the most critical metrics.
- Data Transmission: It ensures reliable data transmission and low latency.
- Data Storage: The processed data is then exported to various backend systems for further analysis, visualization, and storage. It can be stored in data lakes for long-term analysis and historical comparison. The collector supports multiple data formats and protocols, making it compatible with different monitoring and analytics tools. The analysed data can be presented through interactive dashboards and reports, providing actionable insights to network administrators.

Telemetry Modes

The Junos Telemetry supports telemetry sessions in two modes:

- "Dial-in mode" on page 21
- "Dial-out mode" on page 87

Juniper devices can operate in both dial-in and dial-out modes. You can configure the Juniper device in either mode based on your network's topology. Both modes use the same data models and stream the same telemetry data over the network. The difference between the two modes is based on whether the collector or Juniper device initiates and maintains the connection.

Subscription Types

Junos Telemetry supports various subscription modes, enabling tailored data collection based on specific needs and conditions. The subscription modes are configured on the device using CLI commands or are a part of the subscription request based on the telemetry type. These modes determine the behavior of the data stream. Implementation of subscription modes depends on whether you are using a dial-out or a dial-in connection. Streaming intervals determine the frequency of telemetry data transmission between the device and the collector. Data collection and streaming are triggered when certain conditions are met or events occur that initiate the collection and streaming of telemetry data. These triggers ensure that data is collected when specific criteria are met. For example, telemetry data can be collected and streamed when packet loss is detected. Both dial-in and dial-out telemetry support the following subscription modes:

- **Once**: This is a one-time request for telemetry data. You can configure this mode when a snapshot of the current state of the subscribed data is required. It is supported in both dial-in and dial-out connections but is primarily used in dial-in connections. The device sends the data once to the collector and stops for a dial-out connection. The collector requests dial-in connections through a "Subscribe" RPC with ONCE mode. In a dial-out connection, you must configure a sensor and subscription to trigger only once, which is not a common scenario. In dial-in connection, it is like a "Get" RPC but framed as a subscription.

- **Poll**: Is periodic on-demand retrieval of telemetry data. This configuration is suitable for monitoring sensors at specific intervals. POLL is supported in a dial-in scenario, where the collector initiates the connection to the device’s gNMI server. It is not a typical dial-out streaming mode, as Junos Telemetry streaming is device-driven. It requires the device to run a gNMI server. The collector subscribes with POLL and then polls as needed.

- **Stream**: This ongoing subscription continuously streams data when configured triggers occur.

Note: Not all sensors (OpenConfig or native) support all modes.

Streaming Telemetry Subscription Modes

Streaming telemetry supports the following subscription modes:

- **ON_CHANGE:** The device sends updates only when the monitored data changes (for example, an interface counter increments or a state flips). This mode is suitable for event-driven metrics rather than time-driven. Native sensors have an edge over Openconfig sensors in the context of event-driven metrics.

- **SAMPLE:** Telemetry updates are streamed at regular intervals based on the configured interval. This mode is suitable for metrics like packet counts or bytes transferred, which are sampled over time.

- **TARGET_DEFINED**: The device decides the best mode (SAMPLE or ON_CHANGE) based on the monitored sensor or resource. Juniper's implementation may default to SAMPLE unless ON_CHANGE is explicitly supported for the sensor.
  - **NOTE:** The TARGET_DEFINED subscription requests for configuration paths are treated as ON_CHANGE requests only.

Determine the Appropriate Telemetry Configuration for your Network

Consider the following guidelines before selecting the telemetry sensors, connection method (dial-in or dial-out), and subscription mode suitable for your network topology:

- A combination of OpenConfig sensors and the subscription mode SAMPLE is ideal for standardized, periodic monitoring (for example, multivendor dashboards).
- A combination of native sensors and ON_CHANGE subscription mode is suitable for Juniper-specific and event-driven insights (for example, troubleshooting hardware).

To determine the appropriate telemetry session for your network, the following information summarizes a comparison between dial-in and dial-out telemetry modes:

Dial-In versus Dial-Out

- Dial-in (gRPC with gNMI) pulls snapshots from either sensor type (OpenConfig or Native).

  Example: Collector uses gNMI over gRPC to pull OpenConfig statistics (*/interfaces*) or native statistics *(/junos/system/linecard*).

- Dial-out (gRPC or UDP) streams updates from sensors to the collector.

  Example: Device streams OpenConfig BGP stats over gRPC, or native firewall counters over UDP.

Telemetry Protocols

The Junos Telemetry supports the gNMI and UDP protocols to collect and stream telemetry data from Juniper devices to the data collector.

gRPC Network Management Interface (gNMI)

The gNMI is a protocol based on gRPC that configures and monitors network devices. Network operators can retrieve and modify device configuration data and subscribe to real-time telemetry data from network devices. gNMI supports subscription modes such as ONCE, POLL, and STREAM for telemetry updates. Using gNMI ensures secure communication using TLS. For more information, see "gNMI Service" on page 25 and "Subscribing to Telemetry Data Using gNMI" on page 28.

User Datagram Protocol (UDP)

Streaming telemetry Data over UDP is based on the dial-out mechanism. The sensor paths are configured through the CLI, and the device sends the data for the configured sensor paths over UDP to the collector's destination address. The destination address is configured through the CLI. Junos Telemetry supports streaming of telemetry data in two formats Native Protocol Buffers Format or gNMI-Based Message Format. UDP is suitable for exporting stateless data. For more information, see "Streaming Telemetry Data Over UDP" on page 88.

Data Models

The Junos Telemetry data models define the structure of telemetry data collected from network devices, using YANG (Yet Another Next Generation). YANG is a standards-based, extensible data modeling language used in Junos Telemetry to define configuration, operational state data, and remote procedure calls (RPCs) for network devices. In Junos Telemetry, YANG models express the structure and details of Native or OpenConfig data models which contain the sensors such as interface statistics.The YANG standard is defined in RFC 6020 and RFC 7950.

Juniper Networks publishes YANG modules for Junos devices, which can be downloaded from the Juniper GitHub repository. From release 23.4 onwards configuration and telemetry YANG models are merged and published in the Juniper GitHub repository. This contains YANG definitions for configuration, RPCs and telemetry models.

The OpenConfig working group defines the OpenConfig data model. It is a vendor-neutral data model to configure and manage the network. OpenConfig data model generates data as Google Protocol Buffers (GPB) messages in a universal key/value format. Junos Telemetry allows you to leverage OpenConfig models for a broader, vendor-agnostic view of your network. Openconfig sensor paths are used to retrive sensor information from sensors based on the Openconfig data model. For detailed Openconfig resource path exploration, see Junos YANG Data Model Explorer.

The Juniper native data model is an open and extensible framework developed by Juniper. This model is used to stream telemetry data about the unique features found on Juniper devices. These include interface statistics, routing information, security metrics, and so on. Additionally, the native model allows for the definition of enterprise-specific sensors. To access information from Juniper or enterprise-specific sensors, subscribe to Juniper native sensors. Native sensor paths are used to retrive sensor information from sensors based on the native data model. Juniper’s YANG modules for native sensors are available at Juniper's YANG repository on GitHub.

Explore Sensor Paths

A telemetry sensor path describes the hierarchical path to the data points or metrics that need to be monitored. It is used to identify, activate, and stream the relevant data. Junos Telemetry supports both Openconfig and native sensor paths:

- Openconfig Sensor Paths

  To configure data collection from Openconfig sensors, define the subscriptions and sensor paths (for example, `/interfaces/interface/state/counters`), set up the data collector, and download the Junos Telemetry protocol buffers files from the Juniper Networks support page. Capture and decode the captured data on the collector.

- Native Sensor Paths

  Native sensor paths are specific to Junos OS (for example, `/junos/system/line card/interface/`) and offer granular, Juniper-optimized access to device-specific metrics.

  The subscription modes are configured on the device using CLI commands or are a part of the subscription request based on the telemetry type. Use the protocol buffer's files to decode the sensor data on the collector.

Both path types enable the structured output of data in formats such as JSON or XML, ensuring compatibility with external collectors for efficient monitoring and analytics.

Sensor Path Explorer

The Juniper Networks Junos YANG Data Model Explorer is an online tool for viewing all the supported resource paths, their corresponding leaves, and the device platforms that support them. It enables you to explore or compare various OpenConfig and Native data model attributes. Use the filter option based on the software release number or product to view the list of resource paths and sensors on each platform.

> **NOTE**: The Junos YANG Data Model Explorer was introduced in the 23.2R2-S2 releases. From releases 20.2R1 up to 23.1R1, the sensor information is available in the Junos Telemetry Sensor Explorer.

Selecting Telemetry Sensor Paths

In a model-driven telemetry system, the sensor path can be configured to end at any level within the data model's container hierarchy. Based on the required telemetry information, you can configure the sensor path to retrieve a broad data set or be very specific and retrieve targeted information for a particular sensor. For example, a sensor path might point to a container that includes all interface statistics on a router, or it could be more granular, focusing on a single metric like packet loss on a specific interface.

For example, to receive telemetry data about alarms generated on the device (using the OpenConfig data model), you can configure either of the following resource paths based on the granularity of sensor data required:

- `/system/alarms/alarm/id`: This path retrieves only the alarm ID.
- `/system/alarms/alarm/config`: This path retrieves the detailed alarm information.

Configuring the correct sensor paths ensures an efficient telemetry system. Each resource path enables data streaming for the system resource globally, that is, systemwide. You can modify each resource path to specify a logical or physical interface. The resource path "`/interfaces/interface/config`" retrieves the list of configurable items at the global, physical interface level, whereas the path "`/interfaces/interface/config/name`" specifies the name of the interface, and the device may restrict the allowed values for this leaf depending on the type of the interface.

Important Guidelines for Selecting Sensor Paths

You must always provide the complete and direct resource path when configuring sensors. Providing partial resource paths, such as "`/components/component/`", results in incomplete configurations and potential errors. Such resource paths can impose a significant load on the device, as it must retrieve and display all available options within that hierarchy.To prevent this, always verify and use the full resource path to ensure precise and efficient sensor configuration.

> **NOTE**: Use the hierarchical component naming convention for system components to align with OpenConfig standards. This convention allows for precise component identification, using a full path starting from the root node, such as `CHASSIS0:REx` for Routing Engines and `CHASSIS0:FPCx:PICy:NPUz` for Network Processing Units (NPUs). SLAX conversion scripts have been updated to incorporate wildcards and regular expressions, replacing previously hardcoded fields. For more information on component naming conventions, see https://www.juniper.net/documentation/us/en/software/junos/interfaces-fundamentals/topics/topic-map/router-interfaces-overview.html.

> **NOTE**: Creating subscription and sensor configuration at the "/" (root) and "`/junos/`" is not allowed.

> **NOTE**:

Table 1: Sensor Path Example

Complete Sensor Path (Recommended)	Partial Sensor Path (Not Recommended)
`/interfaces/interface/subinterfaces/subinterface/state/counters/out-pkts`	`/interfaces/interface`

NOTE: The logical and physical Packet Forwarding Engine interface sensors report some leaves inconsistently to the collector. For example, the subscribed path `/interfaces/interface/` producing the streamed path `/junos/system/linecard/interface/logical/ usage/` reports key name leaves `parent_ae_name` and `init_time` (with underscores in the leaf name). The subscribed path `/interfaces/interface/state/` producing the streamed path `/ junos/system/linecard/interface/queue/` reports key name leaves `parent-ae-name` and `init-time` (with hyphens in the leaf name).

NOTE: The performance of Junos Evolved devices is optimized through a service-based architecture, in which some processes or daemons are activated based on service configuration. These processes remain inactive until the service is configured. If a telemetry subscription targets an inactive service, no telemetry output will be generated.

Sensor Data Encapsulation Format

The Junos telemetry supports two ways of exporting data in the protocol buffers (gpb) format. This section describes the data format used by native sensors when exporting telemetry data over UDP. The data is encapsulated into a UDP header, which is further encapsulated in the IPv4 payload. This telemetry model follows a distributed architecture, where data generated by configured sensors is exported directly from the data plane. By bypassing the control plane, this approach helps conserve control plane resources for other critical functions.

A native sensor exports data close to the source using UDP. Various types of telemetry data, such as physical interface statistics, firewall filter counter statistics, or statistics for label-switched paths (LSPs) can be exported. A sensor starts to emit data as soon as it is enabled.

The sensor data is represented as a single structured protocol buffers message, named `TelemetryStream`. The message, or `.proto` file, shown below, includes several attributes that identify the data source, such as a line card, a Packet Forwarding Engine, or a Routing Engine. The name of the configured sensor is also included. For more information about how to configure sensors, see "Explore Sensor Paths" on page 9. For a a list of supported native sensors, see *sensor (Junos Telemetry Interface)*.

You must also download the `.proto` files for all the sensors supported to a streaming server or collector. From a web browser, navigate to the All Junos Platforms software download URL on the Juniper Networks page: https://www.juniper.net/support/downloads/. After you select the name of the Junos OS platform and the release number, go to the **Tools** section and download the **Junos telemetry interface Data Model Files** package. For more information about configuring a streaming-server, see *streaming-server (Junos Telemetry Interface)*.

Protobuf Compact Message Format (Juniper Proprietary)

The information streamed to the collector is sent using the top-level message structure of `TelemetryStream` (*telemetry_top.proto file*). The message contains the metadata of the sensor data being streamed (for example, sensor path, the system from where data is being sent, the node from where data is sent, and so on). The actual sensor data is sent as an extension to the top-level message. A separate proto file is sent for the sensor data. The *telemetry_top.proto* file and the sensor proto file are used to decode the sensor data at the collector.

Structure of *telemetry_top.proto* File

```
message TelemetryStream {
    required string system_id = 1
[(telemetry_options).is_key = true];
    optional uint32 component_id = 2
[(telemetry_options).is_key = true];
    optional string sensor_name = 4
[(telemetry_options).is_key = true];
    ….
    optional EnterpriseSensors enterprise = 101;
}
message EnterpriseSensors {
    extensions 1 to max;
}
extend EnterpriseSensors {
    // re-use IANA assigned numbers
    optional JuniperNetworksSensors juniperNetworks = 2636;
}
message JuniperNetworksSensors {
extensions 1 to max; → ends with the extension message
```

```
}
```

NOTE: This file ends with the `extension` message.

Structure of Sensor Proto File

This file begins with the `extension` message.

```
extend JuniperNetworksSensors { → begins with the extension message
    optional Port jnpr_interface_ext = 3;
}
message Port {
    repeated InterfaceInfos interface_stats = 1;
}
message InterfaceInfos {
    required string if_name = 1
[(telemetry_options).is_key = true];
    optional uint64 init_time = 2;
    …..
}
```

The `TelemetryStream` message also includes optional nested structures that carry different types of data. The nested structures can also carry privately defined sensor data such as `EnterpriseSensors`. See the example below:

```
//
// This file defines the top level message used for all Juniper
// Telemetry packets encoded to the protocol buffer format.
// The top level message is TelemetryStream.
//

import "google/protobuf/descriptor.proto";

extend google.protobuf.FieldOptions {
    optional TelemetryFieldOptions telemetry_options = 1024;
}

message TelemetryFieldOptions {
```

```
    optional bool is_key            = 1;
    optional bool is_timestamp      = 2;
    optional bool is_counter        = 3;
    optional bool is_gauge          = 4;
}

message TelemetryStream {
    // router name or export IP address
    required string system_id       = 1 [(telemetry_options).is_key = true];

    // line card / RE (slot number)
    optional uint32 component_id     = 2 [(telemetry_options).is_key = true];

    // PFE (if applicable)
    optional uint32 sub_component_id = 3 [(telemetry_options).is_key = true];

    // configured sensor name
    optional string sensor_name      = 4 [(telemetry_options).is_key = true];

    // sequence number, monotonically increasesing for each
    // system_id, component_id, sub_component_id + sensor_name.
    optional uint32 sequence_number  = 5;

    // timestamp (milliseconds since 00:00:00 UTC 1/1/1970)
    optional uint64 timestamp        = 6 [(telemetry_options).is_timestamp = true];

    // major version
    optional uint32 version_major    = 7;

    // minor version
    optional uint32 version_minor    = 8;

    optional IETFSensors ietf        = 100;

    optional EnterpriseSensors enterprise = 101;
}

message IETFSensors {
    extensions 1 to max;
}

message EnterpriseSensors {
    extensions 1 to max;
```

```
}

extend EnterpriseSensors {
    // re-use IANA assigned numbers
    optional JuniperNetworksSensors juniperNetworks = 2636;
}

message JuniperNetworksSensors {
    extensions 1 to max;
}
```

Individual companies, such as Juniper Networks, define and maintain the attributes generated by enterprise sensors. Each company is assigned a unique attribute identifier. The current convention is to use IANA-assigned enterprise MIB identifiers for each attribute. For Juniper Networks, this assigned identifier is 2636.

NOTE: **Recommended:** To verify that a particular message type has been exported and received, check for those attributes under `TelemetryStream.enterprise.juniperNetworks` in the gpb message.

See Table 2 on page 15 for descriptions of each element collected by sensor data, including semantics and corresponding schema.

Table 2: Individual Data Element Types in the gpb Message

Element Type	Description
Counter	An unsigned integer that increases monotonically. When it reaches its maximum value, it starts back at zero.
Gauge	An unsigned 32-bit or 64-bit integer that can increase or decrease in value. An example of the data represented by this element is the instantaneous value of a specific resource, such as queue depth or temperature.
Rate	Rate at which a base metric changes, such as a counter or a gauge. For this element type, units of measurement are defined explicitly (such as bits per second), as well the interval over which the rate is collected.

Table 2: Individual Data Element Types in the gpb Message *(Continued)*

Element Type	Description
Average	The average of several samples of a base metric. For example, an *average queue depth* data element would be calculated by averaging several elements of the queue depth. For this element type, we strongly recommend defining the number of measurements used to compute the average, as well as the time interval between the measurements. Otherwise, you should define explicitly the means by which this average value is calculated.
Peak	Maximum value among several samples of a base metric. For example, a *peak queue depth* element would be calculated by comparing several measurements of the queue depth and selecting the maximum. For this data element type, we strongly recommend that you define the number of measurements used to compute the peak value, as well as the time interval between measurements. Otherwise, define explicitly how this peak value is defined. You must also know whether this value is never cleared and thus represents the overall maximum value over all time.

NOTE: Each data element type also includes element subsets. For example, the data elements `Counter` and `Gauge` would include subsets for `rate`, `average`, and `peak` measurements.

Supported Data Types

A GetRequest is sent when a collector client initiates a Get RPC to receive telemetry data. Specified within the GetRequest are the data elements with which the target should return data to the collector, including the data type. The data type is the variable that specifies the form in which data should be delivered.

Table 3 on page 17 lists the data types supported by Junos telemetry . Unless specified, the data type is supported for Junos Telemetry data export using remote procedure call (gRPC) services, gRPC Network Management Interface (gNMI) services, or through UDP.

Table 3: Data Types

Type	Value	Description
string	`string_val = 1`	String value.
int64	`int_val = 2`	Integer value.
uint64	`uint_val = 3`	Unsigned integer value.
bool	`bool_val = 4`	Bool value.
float	`float_val = 6`	Floating point value. **NOTE**: This data type is deprecated. Use `double_val` instead of this data type.
double	`double_val`	A double value is a 64-bit floating point value.

Decimal64	`decimal_val = 7)`	Decimal64 encoded value. Supported only with gNMI services. Use decimal64 to encode a fixed precision decimal number. The value is expressed as a set of digits with the precision specifying the number of digits following the decimal point in the digit set. For example:
		
		`message Decimal64 {`
		`  int64 digits = 1;         // Set of digits.`
		`  uint32 precision = 2;     // Number of digits following the`
		`decimal point.`
		
		NOTE: This data type is deprecated. Use `double_val` instead of this data type.

ScalarArray	`leaflist_val = 8`	Mixed type scalar array value. An homogenous array of the values of mixed datatypes (string, int64, uint64, bool float or decimal64). Supported only with gNMI services.

Table 4: Open Config Data Type

Type	Value	Description

ieeefloat32	Binary, length = 4	An IEEE 32-bit floating point number. This is a Open Config model data type.
		
		The format of this number is of the form:
		
		`1-bit sign`
		`8-bit exponent`
		`23-bit fraction`
		`The floating point value is calculated using:`
		`(-1)**S * 2**(Exponent-127) * (1+Fraction)";`
		
		NOTE: The gNMI data type equivalent to binary format is "byte." In a gNMI response, data was incorrectly received from a device in float_val format, and a non-compliance error was displayed. Changes have been incorporated to return data in the bytes_val format. The four bytes (that represent a floating-point value) are sent in network byte order. Ensure to reorder them in host byte order before interpreting the value.

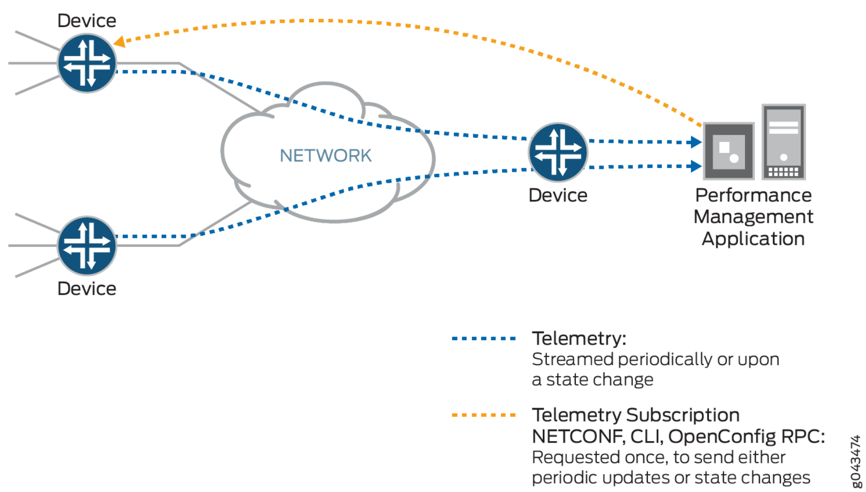
For more information on data types, see github and http://www.openconfig.net/.

Performance Monitoring using Junos Telemetry

One primary function of the Junos Telemetry is performance monitoring. Streaming data to a performance management system enables network administrators to measure trends in link and node utilization, and troubleshoot issues such as network congestion in real time.

In a typical deployment, the network element, or device, streams duplicate data to two destination servers that function as performance management system collectors. Streaming data to two collectors provides redundancy. See Figure 1 on page 19 for an illustration of how the performance management system collectors request data and how the device streams data. The device provisions sensors to collect and export data using command-line interface (CLI), configuration through NETCONF, or gRPC subscription calls. The collectors request data by initiating a telemetry subscription. Data is requested only once and is streamed periodically.

Figure 1: Telemetry Streaming for Performance Management



Other applications of the Junos Telemetry include providing real-time data to support operational state synchronization between a network element and an external controller, such as the Northstar Controller, which automates the creation of traffic-engineering paths across the network. The NorthStar Controller can subscribe to telemetry data about certain network elements, such as label-switched path (LSP) statistics.

2

PART

Dial-in Telemetry

Understanding Dial-in Telemetry

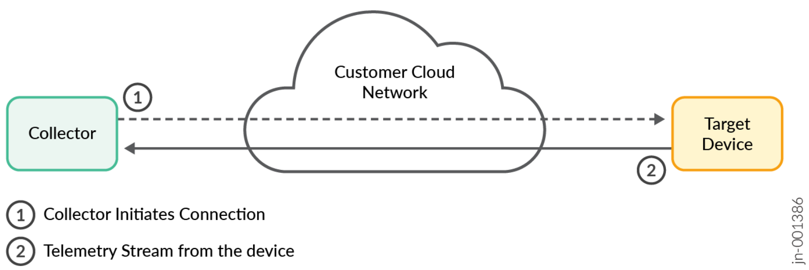
SUMMARY

Dial-in telemetry is a network monitoring method where the collector initiates the connection to the device to retrieve telemetry data. The collector "dials in" to the network device and typically using protocols like gRPC to request and receive data.

IN THIS SECTION

In dial-in mode, the data collector initiates the connection to the network device and subscribes to telemetry data. The collector and the device establish a session. The device streams data to the collector at configured intervals. This mode is commonly used when operators require a unified channel for both configuration and operational data.

Figure 2: Dial-in Telemetry



The Junos Telemetry supports both gNMI and Juniper Extension Toolkit (JET) dial-in connections over gRPC transport.

NOTE: You can use gNMI in a dial-in fashion for on-demand requests (for example, a one-time “get” operation to fetch data). For gNMI dial-in connections, you must enable the gNMI service. The POLL (the collector polls snapshots), and ONCE (a single snapshot) subscription modes are supported. The device usually initiates gRPC for streaming telemetry in Junos Telemetry.

gRPC Service

IN THIS SECTION

gRPC is an open-source framework that provides secure and reliable data transport. You can use a set of Remote Procedure Call (RPC) interfaces to configure the Junos Telemetry and stream telemetry data using the gRPC framework. gRPC remote procedure calls are used to provision sensors and to subscribe to and receive telemetry data. OpenConfig supports the YANG data models. The OpenConfig data model generates data as Google Protocol Buffer (.gpb) messages in a universal key/value format.

NOTE: Starting in Junos OS Release 18.2R1, OpenConfig-based routing engine (RE) sensors can stream data as gpb-structured messages over UDP.

Use gRPC to Stream Data

According to the OpenConfig specification, only gRPC-based transport is supported for streaming data. The gRPC server terminates the gRPC sessions from the management system that is running the client. RPC calls trigger the creation of Junos OS sensors, which either stream data at regular intervals or report specific events. These sensors then forward updates through the appropriate gRPC channel.

NOTE: Starting from Junos OS Release 18.2R1, when an external streaming server, or collector, provisions sensors to export data through gRPC on devices running Junos OS, the sensor configuration is committed to the `junos-analytics` instance of the ephemeral configuration database. The configuration can be viewed by using the `show ephemeral-configuration instance junos-analytics` operational command. In earlier releases, the sensor's configuration is committed to the default instance of the ephemeral configuration database.

NOTE:

The Juniper Telemetry header, previously exported as part of telemetry updates, is now exported as an extension header.

- Use `GnmiJuniperTelemetryHeader.proto` to decode updates from devices running **Junos OS Release 19.3 or earlier**.
- Use `GnmiJuniperTelemetryHeaderExtension.proto` for devices running **Junos OS Release 19.4 or later**.

See Table 5 on page 23 for a list and descriptions of the RPCs implemented to support the Junos Telemetry solution.

Table 5: Telemetry RPCs

RPC Name	Description
`telemetrySubscribe`	Specify telemetry parameters and stream data for the specified list of OpenConfig paths.
`getTelemetrySubscriptions`	Retrieve the list of subscriptions that are created through `telemetrySubscribe`.
`cancelSubscription`	Unsubscribe a subscription created through `telemetrySubscribe`.

Data streamed through gRPC is formatted in OpenConfig key-value pairs in protocol buffers (.gpb) messages. In this universal format, keys are strings that correspond to the path of the system resources in the OpenConfig schema for monitored devices. Values correspond to integers or strings that identify the operational state of the system resource, such as interface counters.

NOTE: Starting in Junos OS Release 18.2R1, data streamed through gRPC can be formatted as protobuf in addition to key-value pairs for OpenConfig-based Routing Engine (RE) sensors. These sensors are in addition to the Packet Forwarding Engine (PFE) sensors.

The following shows the universal key/value format:

```
message KeyValue {
    string key        = 1 [(telemetry_options).is_key = true];
    uint64 int_value  = 2;
    string str_value  = 3;
    string prefix_str = 4;
}
```

```
message TelemetryStream {
    // router name or export IP address
    required string system_id     = 1 [(telemetry_options).is_key = true];

    // line card / RE (slot number)
    optional uint32 component_id  = 2 [(telemetry_options).is_key = true];

   // PFE (if applicable)
    optional uint32 sub_component_id = 3 [(telemetry_options).is_key = true];

   // timestamp (common to all entries in the kv array)
    optional uint64 timestamp     = 4 [(telemetry_options).is_timestamp = true];

    // key / value pairs
    repeated KeyValue kv;
}
```

The following example shows how a set of counters for an interface can be represented:

```
key = "/interfaces/counters/rx-bytes",     int_value = 1000
key = "/interfaces/counters/tx-bytes",     int_value = 2000
key = "/interfaces/counters/rx-packets", int_value = 10
key = "/interfaces/counters/rx-bytes" ,    int_value = 20
key = "/interfaces/counters/oper-state", str_value = "up"
```

A mapping table maps field names to the OpenConfig key strings.

Enable Junos Telemetry Using OpenConfig

OpenConfig for Junos OS specifies an RPC model to enable Junos Telemetry . This package also includes the required YANG models.

You can locate all YANG data models in a GitHub repository for a given OS and release in a single download package. The package and repository include the native configuration, state, and RPC data models and the OpenConfig and IETF data models supported by that OS. You can also access the YANG data models from the Juniper Networks download site.

Use a web browser to navigate to the All Junos Platforms software download URL on the Juniper Networks webpage: https://www.juniper.net/support/downloads/. From the Network Management tab, scroll down to select OpenConfig. Select the Software tab. Select the appropriate version of OpenConfig module.

The programmatic interface `OpenConfigTelemetry` defines the telemetry gRPC service. The `telemetrySubscribe` RPC specifies the following subscription parameters:

- OpenConfig path that identifies the system resource to stream telemetry data, for example:`/interfaces/interface/state/counters/`
- Interval at which data is reported and streamed to the collector server, in milliseconds, for example: `sample_frequency = 4000`

A streaming server or collector uses the `telemetrySubscribe` RPC to request an inline subscription for data at the specified path. The device then sends telemetry data back on the same connection as the subscription request.

gRPC Server Overview

SUMMARY

Junos Telemetry allows multi-port service configuration, letting you configure multiple sets of telemetry services to listen on different ports.

The Junos Telemetry offers flexible gRPC service configuration capabilities, allowing you to set up multiple gRPC servers, each with distinct services, listening addresses, and ports. These capabilities provide granular control over service management and telemetry data collection. You can configure TLS certificates for each server to ensure secure communication. To configure gRPC server, see *Configure gRPC Services*.

gNMI Service

IN THIS SECTION

The gNMI (gRPC Network Management Interface) is a protocol based on gRPC that configures and monitors network devices. Developed by OpenConfig specifically for network management, gNMI allows network operators to retrieve and modify device configuration data and subscribe to real-time telemetry data from network devices. Data collection is a key task in telemetry solutions. gNMI supports subscription modes such as ONCE, POLL, and STREAM for telemetry updates. gNMI uses the gRPC framework, supports efficient data encoding formats such as Protocol Buffers (protobuf), and ensures secure communication through TLS. YANG models define structure of configuration and telemetry data.

The main components of gNMI are:

- **gNMI Client**: Runs on an external system. It sends gNMI requests to configure the device, retrieve configuration data, and subscribe to telemetry streams.
- **gNMI Server**: Runs on the network device and provides access to telemetry and configuration data. The gNMI server processes the request based on its type. If it is a configuration-management change, the gNMI server updates the device configuration and sends a response to the client. It streams data to the gNMI client if it is a telemetry-data-collection request.

gNMI supports the following Remote Procedure Calls (RPCs) for controlling and monitoring network devices:

- Get: This RPC retrieves the current state of the network device, including configuration and operational data.

  > **NOTE**: Use the `type` option in the gNMI get command to specify the data type to retrieve. The available options are `CONFIG`, `STATE`, and `ALL`. The valid type option is `CONFIG`. Use Encoding to define the value encoding formats that the gNMI protocol supports. Available options include `JSON`, `BYTES`, `PROTO`, `ASCII`, and `JSON_IETF`. The valid encoding options are `JSON_IETF` and `ASCII`. Choosing any other configuration apart from the valid options results in an error message.

- Set: The set RPC modifies the configuration of the network device.
- Subscribe: Use this RPC to subscribe to telemetry data from a network device. The following subscription modes are supported:
  - ONCE: Retrieves the current values only once.
  - POLL: Sends current values whenever a poll message is received.
  - STREAM: Continuously sends updates at specified intervals or when changes occur.

  For more information, see "gNMI Subscription" on page 28
- Capabilities: Use this RPC to discover the device's capabilities, such as supported models and encodings.

gNMI Origin

The `Path` message's `origin` field identifies the schema for the path. The `origin` field is encoded as a string. The `<origin, path>` tuple uniquely identifies the path within the message.

The `origin` field is valid in any context of a `Path` message. Typically it is used in the following ways:

- Use a `SetRequest` to indicate that a particular schema modifies the target configuration.
- Use a `GetRequest` to retrieve the contents of a particular schema, or use a `GetResponse` to indicate that the payload contains data from a particular `<origin, path>` schema.
- Use a `SubscribeRequest` to subscribe to paths within a particular schema, or use a `SubscribeResponse` to indicate that an update corresponds to a particular `<origin, path>` tuple.

When a message uses more than one `origin`, do not specify a path in the `prefix`, because the `prefix` applies to all paths in the message. When a `prefix` is specified, include any required `origin`. Do not specify `origin` in both the `prefix` and the path fields in a single request for any RPC payload message.

Special Values of Origin

Origin values are agreed out-of-band to the gNMI protocol. Where the `origin` field is unspecified, its value must default to `openconfig`. It is recommended that the origin is explictly set.

Definition of `origin` for YANG-modelled Data

The `openconfig-extensions:origin` field may be utilised to determine the origin within which a particular module is instantiated.

NOTE: `origin` is distinct from `namespace`. While a YANG namespace is defined at any depth within the schema tree, an `origin` is only used to disambiguate entire schema trees. That is to say, any element that is not at the root inherits its `origin` from its root entity, regardless of the YANG schema modules that make up that root.

Partial Specifications of Origin in Set

If a `Set` RPC specifies `delete`, `update`, or `replace` fields which include an `origin` within their `Path` messages, the corresponding change must be constrained to the specified origin in the following ways:

- `replace` operations must only replace the contents of the specified `origin` at the specified path. Origins that are not specified within the `SetRequest` must not have their contents replaced. In order for a `replace` operation to replace any contents of an `origin` it must be explicitly specified in the `SetRequest`.

- `delete` operations must delete only the contents at the specified path within the specified `origin`. To delete contents from multiple origins, a client must specify multiple paths within the `delete` of the `SetRequest`.

These rules apply where origins represent data that does not overlap. In some cases (for example, CLI and OpenConfig) origins may reflect different 'views' on the same data, and thus their interaction is more complex.

Transactionality of Sets with Multiple Origins

When a `SetRequest` specifies more than one origin (in other words, when it includes two or more operations whose paths reference different origins), all affected data trees must be treated as a single transaction. The `SetResponse` should indicate success only if all operations succeed. If any operation fails, changes across all origins must be rolled back, and an error status must be returned in response to the `Set` RPC.

gNMI Subscription

SUMMARY

This section describes the subscription modes supported by gNMI connections.

IN THIS SECTION

The gNMI protocol defines the `Subscribe` RPC for subscribing to telemetry data. The telemetry collector uses this RPC to request updates from the network device for state and configuration data.

Requests for new subscriptions are encapsulated within a `SubscribeRequest` message containing one or more resource paths. The subscribed paths relate to specific data instances on the target network device. The request can contain paths based on the OpenConfig or native Junos® OS schemas.

The subscription request must also include one of the following modes:

- `ONCE` - a one-time request for data.
- `POLL` - for periodic, on-demand retrieval of data.
- `STREAM` - a long-lived subscription that streams data according to specified triggers.

Subscriptions in `STREAM` mode must specify one of the following sub-modes:

- ON_CHANGE - data updates are only sent when the value of the data item changes.
- SAMPLE - data updates are sent once per sample interval based on an interval period specified in the subscription request. The default sample interval is 30 seconds.
- TARGET_DEFINED - the network device receiving the subscription request determines the best type of delivery for the data on a per-leaf basis. If the path specified within the message refers to event-driven data, then an ON_CHANGE subscription might be created. For data that represents counter values, a SAMPLE subscription might be created.

> **NOTE**: The TARGET_DEFINED subscription requests for configuration paths are treated as ON_CHANGE requests only.

For ONCE, ON_CHANGE and SAMPLE subscriptions, the collector can request an initial update containing the current state of the paths in the subscription. An initial sync update is valuable because:

- The collector has a complete view of the current state of every field on the device for that sensor path.
- Event-driven data (ON_CHANGE) is received by the collector at least once before the next occurs, ensuring that the collector remains aware of the data state beforehand.
- Packet Forwarding Engine sensors that contain zero counter values that normally do not show up in streamed data due to zero-suppression feature are also sent. This ensures that all fields from each line card are known to the collector.

The target device responds to the subscription request with a SubscribeResponse message. If the subscription request calls for an initial sync, the target sends the data followed by the response message with the sync_response flag set to true. After the initial sync, the target device proceeds with updates for the paths according to the subscription mode.

The SubscribeRequest message includes a flag called updates_only. When this flag is set to true, the target device does not send an initial sync, only subsequent updates as follows:

- For STREAM subscriptions in SAMPLE mode, the update is sent at the next sample interval.
- For STREAM subscriptions in ON_CHANGE mode, the update is sent upon the next value change.
- For ONCE subscriptions, only the SubscribeResponse is sent with sync_response set to false, and the subscription closes.
- TARGET_DEFINED subscriptions are treated as ON_CHANGE for configuration paths and the update is sent upon the next value change.

The contents of the `SubscribeRequest` and `SubscribeResponse` messages are defined in gnmi.proto file. For more information on the Subscribe RPC and subscription modes, see the gNMI specification at: gNMI Specification: Subscribing to Telemetry Updates.

NOTE: Configuration paths have these limitations:

- `POLL` subscriptions are not supported.
- Prefix paths are not included in the update messages.
- The gNMI response is not supported for Juniper-specific metadata operations, such as `active/inactive`, `insert before/after`, `comment/annotate`, and `protect/unprotect`. These might appear in the message but are not valid.
- Unsupported parameters in the `SubscribeRequest` include `suppress_redundant`, `heartbeat_level`, `allow_aggregation`, and `qos`.
- PROTO encoding is the only supported encoding.
- Extensions in `SubscribeRequest` messages are not supported
- Subscription path filtering is supported only at a key level.
- The following commit variants are not supported for `ON_CHANGE` and `TARGET_DEFINED` subscriptions:

  `commit at`, `commit prepare/activate`, and batch commits.
- Commits are not supported from the

  `edit dynamic` and `edit private` edit or configure modes.
- Update messages are not sent for presence containers.
- Subscription lists that have only one configured leaf for the identifier or key might not generate an update message.

Enabling "ON CHANGE" Sensor Support Through gNMI

Periodical streaming of OpenConfig operational states and counters is available in Junos to export telemetry data from Juniper equipment to an external collector. Although it is useful in collecting all the needed information and creating a baseline "snapshot," periodical streaming is less useful for time-critical missions. Configure ON_CHANGE streaming for an external collector to receive information only when operational states change.

To support ON_CHANGE streaming, a new specification called gRPC Network Management Interface (gNMI) is implemented for the modification and retrieval of configurations from a network element. Additionally, the gNMI specification can be used to generate and control telemetry streams from a network element to a data collection system. The new gNMI specification allows one gRPC service definition to provide a single implementation on a network element for configuration and telemetry. It also allows a Network Management System (NMS) to interact with the device through unified telemetry and configuration RPCs.

The Junos file package (junos-telemetry-interface) includes the gnmi.proto file and GnmiJuniperTelemetryHeader.proto Juniper extension for gNMI support.

Information about the RPCs supporting this feature is in the gNMI Proto file version 0.4.0 (the supported version) and the specification released

- gNMI Specification: STREAM Subscription
- gNMI Specification: gNMI Protocol

The telemetry RPC `subscribe` under gNMI service supports ON_CHANGE streaming. RPC `subscribe` allows clients to request the target to send values for particular paths within the data tree. Values may be streamed (STREAM), sent one-off on a long-lived channel (POLL), or sent one-off as a retrieval (ONCE).

If you subscribe to a top-level container with a sample frequency of 0, leaves with ON_CHANGE support are streamed based on events. Other leaves are not streamed.

NOTE: To let a device determine which nodes are streamed as ON_CHANGE or which are SAMPLE, the collector must subscribe for TARGET_DEFINED with sample_interval.

Enabling "TARGET_DEFINED" Subscription Mode Through gNMI

Junos OS Release 20.2R1 adds support for TARGET_DEFINED subscription mode with gRPC Network Management Interface (gNMI) services on MX5, MX10, MX40, MX80, MX104, MX150, MX204, MX240, MX480, MX960, MX2008, MX2010, MX2020, MX10003, MX10008, and MX10016 routers.

An external collector that uses a gNMI subscription determines how sensor data is delivered:

- STREAMING mode periodically streams sensor data from the DUT at a specified interval.
- ON_CHANGE mode sends updates for sensor data from the DUT only when data values change.
- Newly supported TARGET_DEFINED mode (submode 0) instructs the DUT to select the relevant mode (STREAMING or ON_CHANGE) to deliver each element (leaf) of sensor data to the external collector. When the external collector sends a subscription for a sensor with submode 0 to the DUT,

the DUT responds, activating the sensor subscription so that periodic streaming does not include any of the ON_CHANGE updates. The DUT notifies the collector whenever qualifying ON_CHANGE events occur.

Subscriptions default to a periodic streaming frequency of 30 seconds unless the collector specifies otherwise in the subscription request.

The JavaScript Object Notation (JSON) file below shows a sample gNMI subscription. TARGET_DEFINED mode is set using `submode=0` for the resource (sensor) path **/interfaces/interface[name='lo0']/state**.

```
$ cat gnmi.json
{
   "dut_list":[
      {

         "port":32767,
         "rpc":["sub_request"],
         "sub_request":{
            "subscription":[
               {
                   "path":"/interfaces/interface[name='lo0']/state",
                  "submode":0,
                  "sample_interval":30
               }
            ],
            "mode":0,
            "encoding":2
         }
      }
   ]
$ python ./gnmi_subscribe_client_sample.py -c ./gnmi.json -d 10.53.32.102 -l client.log
```

The Junos file package (junos-telemetry-interface) includes the gnmi.proto file and GnmiJuniperTelemetryHeader.proto Juniper extension for gNMI support.

For more information, see the gNMI specifications and gNMI protocol file here:

- gNMI Specification: STREAM Subscription
- gNMI Specification: gNMI Protocol

Enabling “INITIAL_SYNC” Subscription Mode Through gNMI

Starting in Junos OS Release 20.2R1, support for INITIAL_SYNC statistics from Packet Forwarding Engine sensors using gNMI services is available. This feature applies to the MX960, MX2008, MX2010, MX2020, PTX1000, and the PTX5000 Router. The Juniper Networks® PTX10000 line of Routers, Juniper Networks® QFX5100 Switch, and Juniper Networks® QFX5200 Switch also provide this support.

Starting in Junos OS Evolved Release 20.4R1, support for INITIAL_SYNC statistics from Packet Forwarding Engine sensors using gNMI services is available. Juniper Networks® QFX5130-32CD Switch includes this support.

When an external collector sends a subscription request for a sensor with INITIAL_SYNC (gnmi-submode 2), the host sends all supported target leaves (fields) under that resource path at least once to the collector with the current value. Collecting these statistics is beneficial because:

- The collector has a complete view of the current state of every field on the device for that sensor path.
- Event-driven data (ON_CHANGE) arrives at the collector at least once before the next event occurs. This approach ensures collector awareness of the data state before the next event occurs.
- Packet Forwarding Engine sensors with zero counter values (zero-suppressed) that normally do not appear in the streamed data are sent atleast once. This approach ensures the collector has visibility into all fields from each line card, often called a source.

INITIAL_SYNC submode requires the device to send at least one copy to the collector, though sending more than one is acceptable.

Subscriptions will default to a periodic streaming frequency of 30 seconds unless otherwise specified by the collector in the subscription request.

The JavaScript Object Notation (JSON) file below shows a sample gNMI subscription. INITIAL_SYNC mode is set using `gnmi_submode 2` for the resource (sensor) path **/interfaces/**. The `gnmi_mode` is set to `0`. The protocol encoding is set to `2` for GBP.

```
{
  "influx": {
    "server": "server1",
    "port": 8086,
    "dbname": "gD40",
    "measurement": "OC",
    "user": "influx",
    "password": "influxdb",
```

```
    "recreate": true
  },
  "gnmi": {
    "mode": 0,     <---- STREAM
    "encoding": 2, <--- PROTO encoding
  "prefix":  "/x/y/z"
  },
  "host": "10.10.130.73",
  "port": 10162,
  "user": "user1",
  "password": "password1",
  "cid": "cid-1jk",
   "paths":[
      {
         "path": "/interfaces/",
         "Freq": 10000000000,
         "gnmi_submode": 2    <----  SAMPLE
      }
   ]
}
```

The Junos file package (junos-telemetry-interface) includes the gnmi.proto file and GnmiJuniperTelemetryHeader.proto Juniper extension for gNMI support.

For more information, see the gNMI specifications and gNMI protocol file here:

gNMI telemetry specification gNMI protocol definition

- gNMI Specification: STREAM Subscription
- gNMI Specification: gNMI Protocol

Examples

IN THIS SECTION

The following examples show subscription requests and responses made by a gNMI client and target device in protobuf format.

Example: ONCE mode

The following example shows a subscription request sent from a gNMI client in protobuf format. The subscription mode is `ONCE` and the OpenConfig resource path is **/system/aaa/authentication/users**:

```
root@controller:~# /usr/local/bin/gnmic sub -a 10.225.0.0:32767 --mode once --path /system/aaa/
authentication/users -u <username> -p <password> --format prototext
```

The target responds with a one-time update:

```
update: {
  timestamp: 1676294840
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "username"
```

```
    }
  }
  val: {
    string_val: "test1"
  }
}
update: {
  path: {
    elem: {
      name: "system"
    }
    elem: {
      name: "aaa"
    }
    elem: {
      name: "authentication"
    }
    elem: {
      name: "users"
    }
    elem: {
      name: "user"
      key: {
        key: "username"
        value: "test1"
      }
    }
    elem: {
      name: "config"
    }
    elem: {
      name: "password"
    }
  }
  val: {
    string_val: "$ABC123"
  }
}
update: {
  path: {
    elem: {
      name: "system"
    }
```

```
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "role"
      }
    }
    val: {
      string_val: "superuser"
    }
  }
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
```

```
        key: {
          key: "username"
          value: "test2"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "role"
      }
    }
    val: {
      string_val: "superuser"
    }
  }
}
```

Example: ON_CHANGE

The following example shows a subscription request in `STREAM` mode with `ON_CHANGE` sub-mode. The OpenConfig resource path is **/system/aaa/authentication/users/user[username="test1"]**:

```
root@controller:~# /usr/local/bin/gnmic sub -a 10.225.0.0:32767 --mode stream --stream-mode on-
change --path /system/aaa/authentication/users -u <username> -p <password> --format prototext
```

The OpenConfig configuration at the time of the subscription request:

```
user@root> show configuration openconfig-system:system aaa authentication | display set
set openconfig-system:system aaa authentication users user test1 config password $ABC123
set openconfig-system:system aaa authentication users user test1 config role superuser
```

The example response message shows the values for the configuration paths and the `sync_response` flag set to `true`:

```
update: {
  timestamp: 1676311979
  update: {
    path: {
```

```
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "password"
      }
    }
    val: {
      string_val: "$ABC123"
    }
  }
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
```

```
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "role"
      }
   }
    val: {
      string_val: "superuser"
    }
  }
}

sync_response: true
```

The following configuration changes are made to the subscribed paths:

- Add username for `test1`.
- Delete password for `test1`.

The target device sends the following update in response:

```
update: {
  timestamp: 1676312428
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
```

```
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "username"
      }
    }
    val: {
      string_val: "test1"
    }
  }
  delete: {
    elem: {
      name: "system"
    }
    elem: {
      name: "aaa"
    }
    elem: {
      name: "authentication"
    }
    elem: {
      name: "users"
    }
    elem: {
      name: "user"
      key: {
        key: "username"
        value: "test1"
      }
    }
    elem: {
```

```
      name: "config"
    }
    elem: {
      name: "password"
    }
  }
}
```

Example: SAMPLE

The following example shows a subscription request in `STREAM` mode and `SAMPLE` sub-mode. The OpenConfig resource path is **/system/aaa/authentication/users/user[username="test1"]**:

```
root@controller:~# /usr/local/bin/gnmic sub -a 10.225.0.0:32767 --mode stream --stream-mode
sample --sample-interval 5s --path /system/aaa/authentication/users -u <username> -p <password>
--format prototext
```

The OpenConfig configuration at the time of the subscription request:

```
user@root> show configuration openconfig-system:system aaa authentication | display set
set openconfig-system:system aaa authentication users user test1 config username test1
set openconfig-system:system aaa authentication users user test1 config password "$ABC123"
set openconfig-system:system aaa authentication users user test1 config role superuser
```

The example response messages show an initial update sent with the `sync_response` flag set to `true` and subsequent updates sent at 5 second intervals:

```
update: {
  timestamp: 1676295454
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
```

```
    }
    elem: {
      name: "users"
    }
    elem: {
      name: "user"
      key: {
        key: "username"
        value: "test1"
      }
    }
    elem: {
      name: "config"
    }
    elem: {
      name: "username"
    }
  }
  val: {
    string_val: "test1"
  }
}
update: {
  path: {
    elem: {
      name: "system"
    }
    elem: {
      name: "aaa"
    }
    elem: {
      name: "authentication"
    }
    elem: {
      name: "users"
    }
    elem: {
      name: "user"
      key: {
        key: "username"
        value: "test1"
      }
    }
```

```
    elem: {
      name: "config"
    }
    elem: {
      name: "password"
    }
  }
  val: {
    string_val: "$ABC123"
  }
}
update: {
  path: {
    elem: {
      name: "system"
    }
    elem: {
      name: "aaa"
    }
    elem: {
      name: "authentication"
    }
    elem: {
      name: "users"
    }
    elem: {
      name: "user"
      key: {
        key: "username"
        value: "test1"
      }
    }
    elem: {
      name: "config"
    }
    elem: {
      name: "role"
    }
  }
  val: {
    string_val: "superuser"
  }
}
```

```
}

sync_response: true

update:
{

  timestamp:
1676295459

  update: {
    path: {
      elem:
{

        name:
"system"

      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem:
{

        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "username"
      }
```

```
    }
    val: {
      string_val: "test1"
    }
  }
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "password"
      }
    }
    val: {
      string_val: "$ABC123"
    }
  }
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
```

```
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "role"
      }
    }
    val: {
      string_val: "superuser"
    }
  }
}



update: {
  timestamp: 1676295464
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
```

```
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "username"
      }
    }
    val: {
      string_val: "test1"
    }
  }
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
```

```
        name: "config"
      }
      elem: {
        name: "password"
      }
    }
    val: {
      string_val: "$ABC123"
    }
  }
  update: {
    path: {
      elem: {
        name: "system"
      }
      elem: {
        name: "aaa"
      }
      elem: {
        name: "authentication"
      }
      elem: {
        name: "users"
      }
      elem: {
        name: "user"
        key: {
          key: "username"
          value: "test1"
        }
      }
      elem: {
        name: "config"
      }
      elem: {
        name: "role"
      }
    }
   val: {
      string_val: "superuser"
    }
```

```
    }
  }
```

RELATED DOCUMENTATION

Explore Sensor Paths | 9

Configure gRPC Services

SUMMARY

Configure the gRPC server to enable a client to use gRPC services on the network device, including: gRPC Network Operations Interface (gNOI) services, gRPC Network Management Interface (gNMI) services, and gRPC Routing Information Base Interface (gRIBI) services.

IN THIS SECTION

This topic discusses how to configure gRPC services on Junos devices, including the options for authentication and how to configure each option. Before the server and client can establish a gRPC session, you must satisfy the requirements discussed in the following sections:

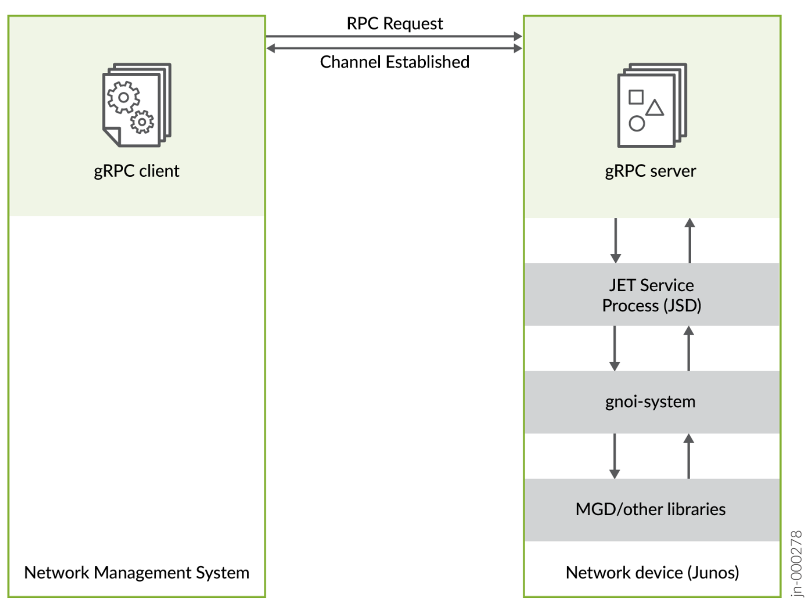
- "Understanding Authentication and Authorization for gRPC-Based Services" on page 51
- "Obtain X.509 Certificates" on page 53
- "Load the gRPC Server's Local Certificate in the Junos PKI" on page 56
- "Enable gRPC Services" on page 57
- "Configure Mutual (Bidirectional) Authentication for gRPC Services" on page 62 (Optional)

- "Configure the User Account for gRPC Services" on page 67
- "Configure gRPC RPC Authorization" on page 68 (Optional)

Understanding Authentication and Authorization for gRPC-Based Services

The gNMI, gNOI, and gRIBI interfaces use the gRPC Remote Procedure Call framework for transport. The gRPC server runs on the network device and listens for connection requests on a specified port. The gRPC client application runs on a remote network management system (NMS) and establishes a gRPC channel with the server on the specified host and port. The client executes RPCs through the SSL-encrypted gRPC session to perform network service operations. Figure 3 on page 51 illustrates a simple connection between a gRPC client and server.

Figure 3: gRPC Server and Client Interaction



gRPC channels use channel credentials to handle authentication between the server and the client. Standard channel credentials use X.509 digital certificates for authenticating the server and the client. A digital certificate provides a way of authenticating users through a trusted third-party called a *certificate authority* or *certification authority (CA)*. The CA verifies the identity of a certificate holder and “signs” the certificate to attest that it has not been forged or altered. The X.509 standard defines the format for the certificate. Digital certificates can be used to establish a secure connection between two endpoints through certificate validation. To establish a gRPC channel, each endpoint (device or application) that requires authentication must supply an X.509 certificate in the exchange.

Junos devices support both server-only authentication as well as mutual authentication for SSL and TLS-based gRPC sessions. When server-only authentication is configured, the server provides its public key certificate when the channel is established. The client uses the server's Root CA certificate to authenticate the server. When mutual authentication is configured, the client also provides its certificate when it connects to the server, and the server validates the certificate. If the certificate validation is successful, the client is allowed to make calls. We recommend that you configure mutual authentication and use CA-signed certificates for the strongest security, although self-signed certificates are accepted.

A public key infrastructure (PKI) supports the distribution and identification of public encryption keys, enabling users to both securely exchange data over networks such as the Internet and verify the identity of the other party. For gRPC-based services, the Junos PKI must contain the certificate for the local device acting as the gRPC server. If you use mutual authentication, the Junos PKI must also contain the Root CA certificates required to validate the certificates of any gRPC clients that connect to the device.

Table 6 on page 52 outlines the general requirements for server-only authentication and mutual authentication when a gRPC client connects to the device to perform gRPC-based services. The gRPC server's certificate must define either the server's hostname in the Common Name (CN) field, or it must define the server's IP address in the Subject Alternative Name (subjectAltName or SAN) IP Address field. The client application must use the same value to establish the connection to the server. If the certificate defines the SubjectAltName IP Address field, the Common Name field is ignored during authentication.

Table 6: Requirements for Server-Only and Mutual Authentication for gRPC Sessions

Requirements	Server-Only Authentication	Mutual Authentication
Certificates	The server must have an X.509 public key certificate. If the client connects to the server's IP address instead of the hostname, the server's certificate must include the subjectAltName (SAN) IP address extension field with the IP address of the server.	The server and client must each have an X.509 public key certificate. If the client connects to the server's IP address instead of the hostname, the server's certificate must include the subjectAltName (SAN) IP address extension field with the IP address of the server.
Junos PKI	The server's local certificate must be loaded in the Junos PKI.	The server's local certificate and each client's Root CA certificate must be loaded in the Junos PKI.

Table 6: Requirements for Server-Only and Mutual Authentication for gRPC Sessions *(Continued)*

Requirements	Server-Only Authentication	Mutual Authentication
Channel credentials	The client must pass in the server's Root CA certificate when the gRPC channel is established.	The client must pass in their certificate and key and the server's Root CA certificate when the gRPC channel is established.

Channel credentials are attached to the gRPC channel and enable the client application to access the service. Call credentials, on the other hand, are attached to a specific service operation (RPC request) and provide information about the person who is using the client application. Call credentials are sent per request, that is, for each RPC call. To execute gRPC-based operations on Junos devices, you must provide call credentials in the request. The user must either have a user account defined locally on the device, or the user must be authenticated by a TACACS+ server, which then maps the user to a user template account that is defined locally on the device. You can provide the call credentials (username and password) in the RPC's `metadata` argument. If authentication is successful, the Junos device executes the RPC request using the account privileges of the specified user.

NOTE: As an alternative to passing in call credentials for every RPC executed on a Junos device, you can use the Juniper Extension Toolkit `jnx_authentication_service` API to log in to the device once at the start of the gRPC session, and all subsequent RPCs executed in the channel are authenticated. You can download the JET Client IDL library from the Juniper Networks download site.

By default, Junos devices authorize an authenticated gRPC client to execute all gRPC RPCs. You can optionally configure a gRPC user's login class to explicitly allow or deny specific gRPC RPCs. To specify the RPCs, you configure the `allow-grpc-rpc-regexps` and `deny-grpc-rpc-regexps` statements and define regular expressions that match the RPCs. See "Configure gRPC RPC Authorization" on page 68 for more information.

Obtain X.509 Certificates

A gRPC session uses X.509 public key certificates to authenticate the gRPC server and client. For server-only authentication, the gRPC server must have a certificate. For mutual authentication, both the gRPC server and client must have certificates. The requirements for the certificates are:

- The certificate can be signed by a CA or self-signed.
- The certificate must be PEM-encoded.

- The gRPC server's certificate must define either the gRPC server's hostname in the Common Name (CN) field, or it must define the gRPC server's IP address in the SubjectAltName (SAN) IP Address field. The gRPC client must use the same value to establish the connection to the server. If the certificate defines the SubjectAltName IP Address, the Common Name field is ignored during authentication.

To use OpenSSL to obtain the gRPC server's certificate:

1. Generate a private key, and specify the key length in bits.

```
user@nms:~$ openssl genrsa -out server.key 4096
Generating RSA private key, 4096 bit long modulus (2 primes)
...++++
..........................................................................++++
e is 65537 (0x010001)
```

2. If the gRPC client connects to the gRPC server's IP address, update your **openssl.cnf** or equivalent configuration file to define the `subjectAltName=IP` extension with the gRPC server's IP address.

```
user@nms:~$ cat openssl.cnf
# OpenSSL configuration file.
...
extensions              = v3_sign
...
[v3_sign]
subjectAltName=IP:10.53.52.169
```

3. Generate a certificate signing request (CSR), which contains the entity's public key and information about their identity.

```
user@nms:~$ openssl req -new -key server.key -out server.csr
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:US
State or Province Name (full name) [Some-State]:CA
Locality Name (eg, city) []:Sunnyvale
Organization Name (eg, company) [Internet Widgits Pty Ltd]: Acme
```

```
Organizational Unit Name (eg, section) []: testing
Common Name (e.g. server FQDN or YOUR name) []:gnoi-server.example.com
Email Address []:
Please enter the following 'extra' attributes
to be sent with your certificate request
A challenge password []:
An optional company name []:
```

Alternatively, you can provide the CSR information in a single command, for example:

```
user@nms:~$ openssl req -new -key server.key -out server.csr -subj "/C=US/ST=CA/L=Sunnyvale/
O=Acme/OU=testing/CN=gnoi-server.example.com"
```

4. Generate the certificate by doing one of the following:

   - Send the CSR to a CA to request an X.509 certificate, and provide the configuration file to include any additional extensions.

   - Sign the CSR with a CA to generate the certificate, and include the `-extfile` option if you need to reference your configuration file and extensions.

   ```
   user@nms:~$ openssl x509 -req -in server.csr -CA /etc/pki/certs/ServerRootCA.crt -
   CAkey /etc/pki/certs/ServerRootCA.key -set_serial 0101 -out server.crt -days 365 -sha256 -
   extfile openssl.cnf
   Signature ok
   subject=C = US, ST = CA, L = Sunnyvale, O = Acme, OU = testing, CN = gnoi-
   server.example.com
   Getting Private key
   ```

   - Sign the CSR with the server key to generate a self-signed certificate, and include the `-extfile` option if you need to reference your configuration file and extensions.

   ```
   user@nms:~$ openssl x509 -req -in server.csr -signkey server.key -out server.crt  -days
   365 -sha256 -extfile openssl.cnf
   Signature ok
   subject=C = US, ST = CA, L = Sunnyvale, O = Acme, OU = testing, CN = gnoi-
   server.example.com
   Getting Private key
   ```

5. Verify that the certificate's Common Name (CN) field and extensions, if provided, are correct.

```
user@nms:~$ openssl x509 -text -noout -in server.crt
Certificate:
    Data:
        Version: 3 (0x2)
        ...
        Subject: C = US, ST = CA, L = Sunnyvale, O = Acme, OU = testing, CN = gnoi-
server.example.com
        ...
        X509v3 extensions:
            X509v3 Subject Alternative Name:
                IP Address:10.53.52.169
    ...
```

For mutual authentication, repeat the previous steps with the information for the gRPC client to generate the client's key and certificate. The client certificate does not require the SAN IP extension field.

Load the gRPC Server's Local Certificate in the Junos PKI

The network device running the gRPC server must have an X.509 certificate that identifies the device to gRPC clients. To perform gRPC-based services on the Junos device, you must load the public key certificate and key for the local network device in the Junos PKI. After you load the certificate and perform the initial configuration, gRPC clients can then use any microservice to update the certificate. For example, a gRPC client can use the gNOI `CertificateManagement` service to install a new certificate or replace an existing certificate.

To load the local device's certificate and key in the PKI:

1. Download the certificate and key for the device that is acting as the gRPC server to that device.
2. In operational mode, define an identifier and load the local device's certificate and key into the PKI.

```
user@host> request security pki local-certificate load certificate-id certificate-id filename
path-to-certificate-file key path-to-key-file
Local certificate loaded successfully
```

For example:

```
user@host> request security pki local-certificate load certificate-id gnoi-server
filename /var/tmp/server.crt key /var/tmp/server.key
Local certificate loaded successfully
```

3. (Optional) Verify the certificate is present in the PKI database.

```
user@host> show security pki local-certificate certificate-id gnoi-server
LSYS: root-logical-system
Certificate identifier: gnoi-server
  Issued to: gnoi-server.example.com, Issued by: C = US, ST = CA, O = serverRootCAOrg, CN =
serverRootCA
  Validity:
    Not before: 04-13-2022 18:15 UTC
    Not after: 04-13-2023 18:15 UTC
  Public key algorithm: rsaEncryption(4096 bits)
  Keypair Location: Keypair generated locally
```

Enable gRPC Services

IN THIS SECTION

gRPC-based services use an API connection setting based on Secure Socket Layer (SSL) or Transport Layer Security (TLS) technology. For these connections, you must specify a local certificate that identifies the gRPC server.

After you enable gRPC services and specify a local certificate, the network device uses server-only authentication. You can then optionally configure mutual authentication by completing the steps described in "Configure Mutual (Bidirectional) Authentication for gRPC Services" on page 62.

You can configure your network device for gRPC services and specify the local certificate used for server authentication at one of the following hierarchy levels:

- **`[edit system services http servers]`**—Use this statement hierarchy to configure one or more gRPC servers that host different sets of services on unique ports. Additionally, each server can support different listening addresses, certificates, and routing instances.
- **`[edit system services extension-service request-response grpc ssl]`**—Use this statement hierarchy when you require only a single gRPC server that supports all gRPC services on the same listening address and port.

To configure the device for gRPC services, follow the instructions for the hierarchy level that meets your environment's requirements.

`[edit system services http servers]`

To configure one or more gRPC servers at the `[edit system services http servers]` hierarchy level:

1. Navigate to the gRPC servers hierarchy level and specify an identifier for the server.

   ```
   [edit]
   user@host# edit system services http servers server name
   ```

   For example:

   ```
   [edit]
   user@host# edit system services http servers server grpc-server1
   ```

2. Configure the port to use for the gRPC services. The port must be unique for each gRPC server.

   ```
   [edit system services http servers server name]
   user@host# set port port-number
   ```

   For example:

   ```
   [edit system services http servers server grpc-server1]
   user@host# set port 32767
   ```

3. Configure the gRPC services hosted by this server.

   ```
   [edit system services http servers server name]
   user@host# set grpc [service1 service2 ...]
   ```

In this example, the server hosts gNMI services and gNOI services.

```
[edit system services http servers server grpc-server1]
user@host# set grpc [gnmi gnoi]
```

4. Specify the local certificate that identifies the server to a client.

   Enter the identifier for the local certificate that you previously loaded into the Junos PKI with the `request security pki local-certificate load` operational mode command.

   ```
   [edit system services http servers server name]
   user@host# set tls local-certificate certificate-id
   ```

   The following example configures the local certificate `gnoi-server`:

   ```
   [edit system services http servers server grpc-server1]
   user@host# set tls local-certificate gnoi-server
   ```

5. (Optional) Specify the IPv4 or IPv6 address on which the server listens for incoming connections.

   ```
   [edit system services http servers server name]
   user@host# set listen-address address
   ```

   For example:

   ```
   [edit system services http servers server grpc-server1]
   user@host# set ip-address 192.168.2.1
   ```

   NOTE: If you do not specify an IP address, the default address of :: is used to listen for incoming connections.

6. (Optional) Configure the routing-instance to use for this gRPC server, if different from the default routing instance.

   ```
   [edit system services http servers server name]
   user@host# set routing-instance routing-instance
   ```

The following example uses the mgmt-junos routing instance.

```
[edit system services http servers server grpc-server1]
user@host# set routing-instance mgmt-junos
```

7. (Optional) Configure the maximum number of connections that this gRPC server supports.

```
[edit system services http servers server name]
user@host# set max-connections connections
```

The following example configures a maximum of 10 connections. The default is 5.

```
[edit system services http servers server grpc-server1]
user@host# set max-connections 10
```

8. Commit the configuration.

```
user@host# commit
```

To configure mutual authentication instead of server-only authentication, you must also complete the steps in "Configure Mutual (Bidirectional) Authentication for gRPC Services" on page 62.

[edit system services extension-service request-response grpc ssl]

To configure a single gRPC server at the `[edit system services extension-service request-response grpc ssl]` hierarchy level:

1. Navigate to the SSL-based API connection settings for gRPC services.

```
[edit]
user@host# edit system services extension-service request-response grpc ssl
```

2. Configure the port to use for gRPC services.

```
[edit system services extension-service request-response grpc ssl]
user@host# set port port-number
```

For example:

```
[edit system services extension-service request-response grpc ssl]
user@host# set port 32767
```

3. Specify the local certificate that identifies the server to a client.

   Enter the identifier for the local certificate that you previously loaded into the Junos PKI with the `request security pki local-certificate load` operational mode command.

```
[edit system services extension-service request-response grpc ssl]
user@host# set local-certificate certificate-id
```

   The following example configures the local certificate `gnoi-server`:

```
[edit system services extension-service request-response grpc ssl]
user@host# set local-certificate gnoi-server
```

4. Configure the device to use the PKI database for certificates.

```
[edit system services extension-service request-response grpc ssl]
user@host# set use-pki
```

5. Enable the device to reload certificates without terminating the gRPC session.

```
[edit system services extension-service request-response grpc ssl]
user@host# set hot-reloading
```

6. (Optional) Specify an IP address to listen to for incoming connections.

```
[edit system services extension-service request-response grpc ssl]
user@host# set ip-address address
```

For example:

```
[edit system services extension-service request-response grpc ssl]
user@host# set ip-address 192.168.2.1
```

NOTE: If you do not specify an IP address, the default address of :: is used to listen for incoming connections.

7. (Optional) Configure tracing for extension services to debug any issues that might arise.

```
[edit]
user@host# top
user@host# set system services extension-service traceoptions file jsd
user@host# set system services extension-service traceoptions flag all
```

NOTE: To view Junos OS Evolved trace files for extensions services, use the `show trace application jsd` and `show trace application jsd live` operational mode commands.

8. Commit the configuration.

```
user@host# commit
```

To configure mutual authentication instead of server-only authentication, you must also complete the steps in "Configure Mutual (Bidirectional) Authentication for gRPC Services" on page 62.

Configure Mutual (Bidirectional) Authentication for gRPC Services

IN THIS SECTION

You can configure mutual (bidirectional) authentication for gRPC sessions, which authenticates both the network device as the gRPC server and the NMS as the gRPC client using certificates. The Junos device uses the credentials provided by the external client to authenticate the client and authorize a connection.

You can configure mutual authentication on Junos devices using one of the following options:

- Configure the mutual authentication settings directly in the configuration.
- Set up server-only authentication initially, and then use the gNOI `CertificateManagement` service to load the necessary CA certificates on the device.

If you configure mutual authentication directly in the device configuration, the device configuration takes precedence over any setup done using the gNOI services.

Before you begin:

- Load the certificate and key for the network device acting as the gRPC server into the device's PKI as described in "Load the gRPC Server's Local Certificate in the Junos PKI" on page 56.
- Enable gRPC services and configure the local server authentication as described in "Enable gRPC Services" on page 57.

The following sections discuss the different methods for configuring mutual authentication. You can use whichever method works best for your environment.

Configure Mutual Authentication in the Device Configuration

To configure authentication for the gRPC client directly in the network device configuration:

1. Download the root CA certificate that will be used to validate the client' s certificate to the local device acting as the gRPC server.
2. Configure a CA profile for the client certificate's root CA at the `[edit security pki]` hierarchy.

```
[edit security pki]
user@host# set ca-profile ca-profile-name ca-identity ca-identifier
```

For example:

```
[edit security pki]
user@host# set ca-profile gnoi-client ca-identity clientRootCA
```

3. Commit the configuration.

```
[edit]
user@host# commit and-quit
```

4. In operational mode, load the root CA certificate that will be used to verify the client's certificate into the Junos PKI. Specify the `ca-profile` identifier that you configured in the previous steps.

```
user@host> request security pki ca-certificate load ca-profile ca-profile filename cert-path
```

For example:

```
user@host> request security pki ca-certificate load ca-profile gnoi-client filename /var/tmp/
clientRootCA.crt
Fingerprint:
  00:2a:30:e9:59:94:db:f1:a1:5c:d1:c9:d4:5f:db:8f:f1:f0:8d:c4 (sha1)
  02:3b:a0:b8:95:0c:a2:fa:15:18:57:3d:a3:10:e9:ac (md5)

69:97:90:39:de:75:a0:1d:94:1e:06:a8:be:8c:66:e5:41:95:fd:dc:14:8a:e7:3a:e0:42:9e:f9:f7:dd:c8:c
2 (sha256)
Do you want to load this CA certificate ? [yes,no] (no) yes

CA certificate for profile gnoi-client loaded successfully
```

TIP: To load a CA certificate bundle, issue the `request security pki ca-certificate ca-profile-group load ca-group-name` *`ca-group-name`* `filename` *`bundle-path`* command.

After loading the certificate, enter configuration mode and continue configuring mutual authentication. You must configure mutual authentication under the same hierarchy level where you configured your server. Perform the steps outlined in the section for your hierarchy level.

[edit system services http servers]

To configure mutual authentication for a server configured at the `[edit system services http servers]` hierarchy level:

1. Navigate to the `tls` statement under your server configuration.

```
[edit]
user@host# edit system services http servers server name tls
```

For example:

```
[edit]
user@host# edit system services http servers server grpc-server1 tls
```

2. Enable mutual authentication and specify the requirements for client certificates.

```
[edit system services http servers server name tls]
user@host# set mutual-authentication authentication-type requirement
```

For example, to specify the strongest authentication, which requires a certificate and its validation, use `request-and-require-cert-and-verify`, which is also the default.

```
[edit system services http servers server grpc-server1 tls]
user@host# set mutual-authentication authentication-type request-and-require-cert-and-verify
```

3. Specify the CA profile that will be used to verify the client certificate.

The CA profile was configured in step "2" on page 63 of the CA profile configuration.

```
[edit system services http servers server name tls]
user@host# set mutual-authentication certificate-authority certificate-authority
```

For example, to specify the CA profile named `gnoi-client`:

```
[edit system services http servers server grpc-server1 tls]
user@host# set mutual-authentication certificate-authority gnoi-client
```

4. Commit the configuration.

```
[edit system services http servers server name tls]
user@host# commit and-quit
```

[edit system services extension-service request-response grpc ssl]

To configure mutual authentication for a server configured at the `[edit system services extension-service request-response grpc ssl]` hierarchy level:

1. Enable mutual authentication and specify the requirements for client certificates.

   ```
   [edit system services extension-service request-response grpc ssl]
   user@host# set mutual-authentication client-certificate-request requirement
   ```

   For example, to specify the strongest authentication, which requires a certificate and its validation, use `require-certificate-and-verify`.

   ```
   [edit system services extension-service request-response grpc ssl]
   user@host# set mutual-authentication client-certificate-request require-certificate-and-verify
   ```

   NOTE: The default is `no-certificate`. The other options are: `request-certificate`, `request-certificate-and-verify`, `require-certificate`, `require-certificate-and-verify`.

   We recommend that you use the `no-certificate` option in a test environment only.

2. Specify the CA profile that will be used to verify the client certificate.

   The CA profile was configured in step "2" on page 63 of the CA profile configuration.

   ```
   [edit system services extension-service request-response grpc ssl]
   user@host# set mutual-authentication certificate-authority certificate-authority
   ```

   For example, to specify the CA profile named `gnoi-client`:

   ```
   [edit system services extension-service request-response grpc ssl]
   user@host# set mutual-authentication certificate-authority gnoi-client
   ```

3. Commit the configuration.

   ```
   [edit system services extension-service request-response grpc ssl]
   user@host# commit and-quit
   ```

Configure Mutual Authentication Using the gNOI CertificateManagement Service

You can use the gNOI `CertificateManagement` service to set up mutual authentication between the gRPC client and gRPC server instead of configuring the settings directly in the device configuration. You initially set up server-only authentication and then use the gNOI `CertificateManagement` service RPCs to load the client CA certificates. See *gNOI Certificate Management Service* for information about loading the certificates using the gNOI `CertificateManagement` service.

The gRPC server supports only one global CA certificate bundle for gNOI services. When you use the gNOI `CertificateManagement` service to load the CA certificate bundle, the device implicitly uses mutual authentication. However, you should take note of the following:

- The `CertificateManagement` service always loads the CA certificate bundle using the `ca-profile-group` reserved identifier `gnoi-ca-bundle`.
- If you use the `CertificateManagement` service to load the CA certificate bundle, the device implicitly uses mutual authentication.
- If the `CertificateManagement` service sends a request to load a new CA certificate bundle, the server clears the certificates for the previous CA bundle from the device and loads the new ones.
- If you use the `CertificateManagement` service to load a CA certificate bundle and you also explicitly configure mutual authentication in the device configuration, then the configured statements take precedence.

Configure the User Account for gRPC Services

Channel credentials are attached to the gRPC channel and enable the client application to access the service. Call credentials are attached to a specific RPC request and provide information about the user who is using the client application. You must provide call credentials in each RPC request, which requires a user account for the network device. The user must have a user account defined locally on the network device, or the user must be authenticated by a TACACS+ server, which then maps the user to a user template account that is defined locally on the device.

To create a user account:

1. Configure the `user` statement with a unique username, and include the `class` statement to specify a login class that has the permissions required for all actions to be performed by the user. For example:

```
[edit system login]
user@host# set user gnoi-user class super-user
```

2. For local user accounts, configure the user's password.

   You can omit the password for local user template accounts because the user is authenticated through a remote authentication server.

   ```
   [edit system login]
   user@host# set user gnoi-user authentication plain-text-password
   New password:
   Retype new password:
   ```

3. (Optional) Configure the `full-name` statement to specify the user’s name.

   ```
   [edit system login]
   user@host# set user gnoi-user full-name "gNOI client"
   ```

4. Commit the configuration to activate the user account on the device.

   ```
   [edit system login]
   user@host# commit
   ```

5. Repeat the preceding steps on each network device where the gRPC client will execute RPCs in a gRPC session.

Configure gRPC RPC Authorization

By default, Junos devices authorize an authenticated gRPC client to execute all gRPC RPCs. You can configure a Junos login class to explicitly allow or deny gRPC RPCs. To specify the RPCs, you configure the `allow-grpc-rpc-regexps` and `deny-grpc-rpc-regexps` statements and define regular expressions that match the RPCs. If there are conflicting expressions in the allow and deny lists, the deny list takes precedence. If an RPC does not match either list, the RPC is allowed by default.

Junos devices use the following syntax for specifying gRPC RPCs:

```
/package.service/rpc
```

Where *package*, *service*, and *rpc* are the names defined in the respective statement in that service's proto definition file. For example:

```
/gnmi.gNMI/Get
/gnoi.certificate.CertificateManagement/Rotate
/gnoi.system.System/Reboot
/gnoi.system.System/RebootStatus
/gribi.gRIBI/.*
```

You can configure multiple `allow-grpc-rpc-regexps` and `deny-grpc-rpc-regexps` statements with one or more expressions. Enclose each expression within quotation marks (" "). Enclose multiple expressions in square brackets [ ], and separate the expressions with a space.

```
allow-grpc-rpc-regexps ["regex1" "regex2" ... ]
allow-grpc-rpc-regexps "regex3"
```

To create a login class that defines authorization for gRPC RPCs:

1. Configure the login class name and permissions.

   ```
   [edit system login]
   user@host# set class class-name permissions [permission1 permission2 ...]
   ```

   For example:

   ```
   [edit system login]
   user@host# set class grpc-operator permissions all
   ```

2. Within the class, configure regular expressions for the RPCs that the class allows.

   ```
   [edit system login class class-name]
   user@host# set allow-grpc-rpc-regexps ["regex1" "regex2" ... ]
   user@host# set allow-grpc-rpc-regexps "regex3"
   ```

   For example, the following statement allows the gNMI `Get()` RPC and all gNOI `System` service RPCs.

   ```
   [edit system login class grpc-operator]
   user@host# set allow-grpc-rpc-regexps ["/gnmi.gNMI/Get" "/gnoi.system.System/.*"]
   ```

3. Configure regular expressions for the RPCs that the class denies.

```
[edit system login class class-name]
user@host# set deny-grpc-rpc-regexps ["regex1" "regex2" ... ]
```

For example, the following statements deny the gNMI `Set()` RPC and also deny all RPCs for the `gRIBI` service as well as the gNOI `CertificateManagement` service.

```
[edit system login class grpc-operator]
user@host# set deny-grpc-rpc-regexps ["/gnmi.gNMI/Set" "/gribi.gRIBI/.*"]
user@host# set deny-grpc-rpc-regexps "/gnoi.certificate.CertificateManagement/.*"
```

4. Assign the login class to the appropriate gRPC users.

```
[edit system login]
user@host# set user username class class-name
```

For example, the following statement assigns the `grpc-operator` class to the `grpc-user` user.

```
[edit system login]
user@host# set user grpc-user class grpc-operator
```

After enabling gRPC services on the network device, set up the remote NMS as a gRPC client. To enable the client to execute gNOI operations, configure the client as outlined in *Configure gNOI Services*.

Change History Table

Feature support is determined by the platform and release you are using. Use Feature Explorer to determine if a feature is supported on your platform.

Release	Description
25.2R1 & 25.2R1-EVO	Starting in Junos OS Release 25.2R1 and Junos OS Evolved Release 25.2R1, you can configure multiple gRPC servers that host different sets of services on unique ports.

Establish a Dial-in Telemetry Connection

SUMMARY

This topic describes the procedure to establish a dial-in telemetry connection. Configure the gRPC service and data collector, and select sensor paths based on the sensor information you want to collect from the Junos device.

IN THIS SECTION

Use the following procedure to establish a dial-in telemetry connection. Configure the gRPC service and data collector, and select sensor paths based on the sensor information you want to collect from the Junos device. In dial-in mode, the data collector initiates the connection to the network device and subscribes to telemetry data. The collector and the device establish a session. The device then streams data to the collector, and you can configure the streaming intervals. Operators who want a single configuration and operational data channel often choose dial-in mode.

Prerequisites:

1. Ensure the Juniper device runs a compatible Junos OS version that supports Junos Telemetry.
2. Set up a gRPC-compatible telemetry collector (for example, Juniper Telemetry Collector, Prometheus, or InfluxDB) to receive and process telemetry data.
3. Ensure the Juniper device and collector can communicate over the network (TCP port 50051 for gRPC (default), or a custom port).
4. If your implementation uses TLS, prepare certificates for the device and collector.
5. For a complete list of sensors supported for your Juniper device, see Junos YANG Data Model Explorer.
   - **Note:** The Junos YANG Data Model Explorer was introduced in the 23.2R2-S2 releases. From releases 20.2R1 up to 23.1R1, the sensor information is available in the Junos Telemetry Sensor Explorer.
6. Configure gRPC services. See *Configure gRPC Services*.

Follow the procedures listed below to establish a dial-in telemetry connection:

Configure the Data Collector

1. The collector must be ready to initiate the connection. Configure the gRPC client to connect to the Juniper device, where:

   - IP Address: the management IP of the device (192.168.1.1).
   - Port: 50051 (or custom port).
   - Protocol: gRPC with gNMI or Juniper® Extension Toolkit JET subscription.
   - Credentials: If TLS is enabled, provide the client certificate and key.
   - Subscription: Specify the sensor paths (for example, /junos/system/linecard/interface/) and subscription mode (for example, stream).

   Install and configure the gNMI client on the collector. Ensure the protobuf definitions are available on the collector. This information is required to decode the sensor data received at the collector. The gNMI client is available on Git Hub, see gNMI Client.

   Run the following command:

   ```
   gnmic -a <device_ip>:<port> subscribe --path <path> --mode stream
   ```

   For example:

   ```
   gnmic -a 192.168.1.1:50051 subscribe --path /junos/system/linecard/interface/ --mode stream
   ```

2. To verify the configuration, you can use `show agent sensors` and `show extension-service request-response clients` commands.
3. On the data collector, verify if the data is received. For example, if Prometheus or Grafana is used as a data collector, check logs or visualizations.

Select Sensor Paths

IN THIS SECTION

Sensor Explorer and Guidelines for Selecting Sensor Paths

Use the Juniper Networks Junos YANG Data Model Explorer to view all the supported resource paths, their corresponding leaves, and the device platforms that support them.

> **NOTE**: The Junos YANG Data Model Explorer was introduced in the 23.2R2-S2 releases. From releases 20.2R1 up to 23.1R1, the sensor information is available in the Junos Telemetry Sensor Explorer.

To search and view other telemetry sensors and specific information about legacy sensors, see "Legacy Sensor Paths" on page 260.

For information on guidelines and best practices for configuring sensor paths, see "Explore Sensor Paths" on page 9.

Decode Data on the Collector

IN THIS SECTION

Decode data on the collector

Use the following procedure to capture data, decode raw data, and use the protocol buffer files to decode data.

To decode data:

1. Capture the data. Run netcat on a destination streaming telemetry server or collector in UDP listener mode to store all incoming datagrams in a file. Use the destination port number configured in the streaming-server profile on your Juniper Networks device.

   ```
   nc -ul 0.0.0.0 20000 > data.gpb
   ```

NOTE: This command stores datagrams into a file named `data.gpb`. Run this program to capture data. When you want to stop receiving data, stop with the program by sending the break signal (`Control + C`)

2. Decode raw data.

NOTE: This step is optional. It is not required if you know the encoded message type of the data.

Decode the message from the `data.gpb` file.

```
protoc --decode_raw  < ../data.gpb
1: "hillrock:160.1.1.25"
2: 0
4: "S1:/junos/system/linecard/interface/logical/usage/:/junos/system/linecard/interface/
logical/usage/:PFE"
5: 65265
6: 1477686534474
7: 1
8: 1
101 {
  2636 {
    7 {
      1 {
        1: "et-0/0/4:2.32767"
        2: 1477642750
        3: 813
        4 {
          12: 0x37363732332e3165
        }


.
.
.
```

The next nested structure under `2636` identifies the sensor type. The numerical value `2636` identifies the `JuniperNetworksSensor` message, which is defined in the `telemetry_top.proto` file. In this example, the numerical identifier `7` corresponds to the `LogicalPort` message defined in the `logical_port.proto` file. Use this information in the next step to generate more detailed output.

3. Decode the message to include field names. Run the protocol buffers compiler with the decode option. Additionally, specify the top-level message type (`TelemetryStream`) and the file with the message definition, `logical_port.proto`. You must also include the protocol buffers (gpb) library.

```
protoc --decode TelemetryStream logical_port.proto -I /usr/include -I .  < data.gpb
system_id: "hillrock:160.1.1.25"
component_id: 0
sensor_name: "S1:/junos/system/linecard/interface/logical/usage/:/junos/system/linecard/
interface/logical/usage/:PFE"
sequence_number: 65268
timestamp: 1477686536484
version_major: 1
version_minor: 1
enterprise {
  [juniperNetworks] {
    [jnprLogicalInterfaceExt] {
      interface_info {
        if_name: "et-0/0/4:2.32767"
        init_time: 1477642750
        snmp_if_index: 813
        parent_ae_name: "ae1.32767"
        ingress_stats {
          if_packets: 0
          if_octets: 0
        }
        egress_stats {
          if_packets: 0
          if_octets: 0
        }
        op_state {
          operational_status: "up"
        }
      }
      interface_info {
        if_name: "et-0/0/7:3.0"
        init_time: 1477642750
        snmp_if_index: 520
        parent_ae_name: "ae0.0"
        ingress_stats {
          if_packets: 61203309
          if_octets: 6487548454
        }
```

```
    egress_stats {
      if_packets: 87416547
      if_octets: 9266153982
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.0"
    init_time: 1477642750
    snmp_if_index: 2512
    ingress_stats {
      if_packets: 26266247
      if_octets: 2784214806
    }
    egress_stats {
      if_packets: 26247215
      if_octets: 2781829290
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.1"
    init_time: 1477642750
    snmp_if_index: 2522
    ingress_stats {
      if_packets: 26266249
      if_octets: 2784214972
    }
    egress_stats {
      if_packets: 26249115
      if_octets: 2781935590
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.2"
    init_time: 1477642750
```

```
    snmp_if_index: 2523
    ingress_stats {
      if_packets: 26266248
      if_octets: 2784214912
    }
    egress_stats {
      if_packets: 26249106
      if_octets: 2781935086
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.3"
    init_time: 1477642750
    snmp_if_index: 2524
    ingress_stats {
      if_packets: 26266248
      if_octets: 2784214820
    }
    egress_stats {
      if_packets: 26248520
      if_octets: 2781902320
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.4"
    init_time: 1477642750
    snmp_if_index: 2525
    ingress_stats {
      if_packets: 26266247
      if_octets: 2784214760
    }
    egress_stats {
      if_packets: 26247302
      if_octets: 2781834112
    }
    op_state {
      operational_status: "up"
```

```
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.5"
    init_time: 1477642750
    snmp_if_index: 2526
    ingress_stats {
      if_packets: 26266247
      if_octets: 2784214760
    }
    egress_stats {
      if_packets: 26247209
      if_octets: 2781828904
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.6"
    init_time: 1477642750
    snmp_if_index: 2527
    ingress_stats {
      if_packets: 26266248
      if_octets: 2784214820
    }
    egress_stats {
      if_packets: 26247196
      if_octets: 2781828226
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.7"
    init_time: 1477642750
    snmp_if_index: 2528
    ingress_stats {
      if_packets: 26266247
      if_octets: 2784214760
    }
    egress_stats {
```

```
      if_packets: 26247203
      if_octets: 2781828618
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.8"
    init_time: 1477642750
    snmp_if_index: 2529
    ingress_stats {
      if_packets: 26266247
      if_octets: 2784214760
    }
    egress_stats {
      if_packets: 26247225
      if_octets: 2781829850
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.9"
    init_time: 1477642750
    snmp_if_index: 2530
    ingress_stats {
      if_packets: 26266247
      if_octets: 2784214760
    }
    egress_stats {
      if_packets: 26247209
      if_octets: 2781828954
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.32767"
    init_time: 1477642750
    snmp_if_index: 648
```

```
    ingress_stats {
      if_packets: 4
      if_octets: 240
    }
    egress_stats {
      if_packets: 0
      if_octets: 0
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/4:2.32767"
    init_time: 1477642750
    snmp_if_index: 813
    parent_ae_name: "ae1.32767"
    ingress_stats {
      if_packets: 0
      if_octets: 0
    }
    egress_stats {
      if_packets: 0
      if_octets: 0
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/7:3.0"
    init_time: 1477642750
    snmp_if_index: 520
    parent_ae_name: "ae0.0"
    ingress_stats {
      if_packets: 61206122
      if_octets: 6487846632
    }
    egress_stats {
      if_packets: 87420567
      if_octets: 9266580102
    }
    op_state {
```

```
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.0"
    init_time: 1477642750
    snmp_if_index: 2512
    ingress_stats {
      if_packets: 26267458
      if_octets: 2784343172
    }
    egress_stats {
      if_packets: 26248420
      if_octets: 2781957020
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.1"
    init_time: 1477642750
    snmp_if_index: 2522
    ingress_stats {
      if_packets: 26267460
      if_octets: 2784343338
    }
    egress_stats {
      if_packets: 26250320
      if_octets: 2782063320
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.2"
    init_time: 1477642750
    snmp_if_index: 2523
    ingress_stats {
      if_packets: 26267459
      if_octets: 2784343278
    }
```

```
        egress_stats {
          if_packets: 26250311
          if_octets: 2782062816
        }
        op_state {
          operational_status: "up"
        }
      }
      interface_info {
        if_name: "et-0/0/13:0.3"
        init_time: 1477642750
        snmp_if_index: 2524
        ingress_stats {
          if_packets: 26267460
          if_octets: 2784343292
        }
        egress_stats {
          if_packets: 26249725
          if_octets: 2782030050
        }
        op_state {
          operational_status: "up"
        }
      }
      interface_info {
        if_name: "et-0/0/13:0.4"
        init_time: 1477642750
        snmp_if_index: 2525
        ingress_stats {
          if_packets: 26267459
          if_octets: 2784343232
        }
        egress_stats {
          if_packets: 26248507
          if_octets: 2781961842
        }
        op_state {
          operational_status: "up"
        }
      }
      interface_info {
        if_name: "et-0/0/13:0.5"
        init_time: 1477642750
```

```
    snmp_if_index: 2526
    ingress_stats {
      if_packets: 26267459
      if_octets: 2784343232
    }
    egress_stats {
      if_packets: 26248414
      if_octets: 2781956634
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.6"
    init_time: 1477642750
    snmp_if_index: 2527
    ingress_stats {
      if_packets: 26267460
      if_octets: 2784343292
    }
    egress_stats {
      if_packets: 26248401
      if_octets: 2781955956
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.7"
    init_time: 1477642750
    snmp_if_index: 2528
    ingress_stats {
      if_packets: 26267459
      if_octets: 2784343232
    }
    egress_stats {
      if_packets: 26248408
      if_octets: 2781956348
    }
    op_state {
      operational_status: "up"
```

```
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.8"
    init_time: 1477642750
    snmp_if_index: 2529
    ingress_stats {
      if_packets: 26267459
      if_octets: 2784343232
    }
    egress_stats {
      if_packets: 26248430
      if_octets: 2781957580
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.9"
    init_time: 1477642750
    snmp_if_index: 2530
    ingress_stats {
      if_packets: 26267459
      if_octets: 2784343232
    }
    egress_stats {
      if_packets: 26248414
      if_octets: 2781956684
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.32767"
    init_time: 1477642750
    snmp_if_index: 648
    ingress_stats {
      if_packets: 4
      if_octets: 240
    }
    egress_stats {
```

```
          if_packets: 0
          if_octets: 0
        }
        op_state {
          operational_status: "up"
        }
      }
    }
  }
}
```

3

PART

Dial-out Telemetry

Understanding Dial-Out Telemetry

SUMMARY

Dial-out telemetry is a method used in network monitoring where the device (for example, a router) initiates the connection to send data to a collector. In dial-out telemetry, the device "dials out" to the collector, which means it sends the initial SYN packet to establish the connection. This approach simplifies network management because it avoids the need to open ports for inbound management traffic.

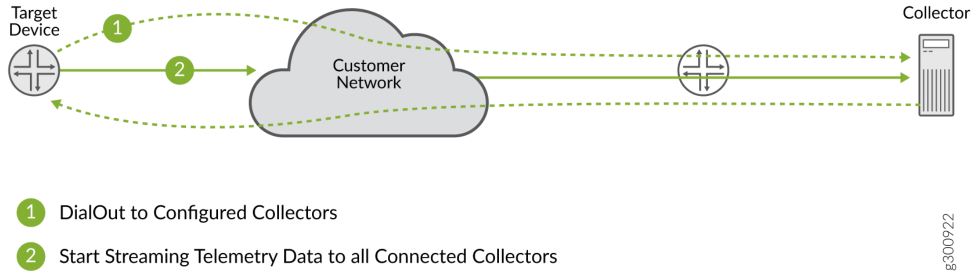
IN THIS SECTION

Starting with Junos OS Release 22.4R1, Junos Telemetry supports remote gRPC dial-out functionality on ACX Series routers, MX Series routers, PTX Series routers, and QFX Series switches. With gRPC dial-out, the target device (server) initiates a gRPC session with the collector (client). The target device (server) initiates a gRPC session with the collector (client) by using gRPC dial-out. When the session is established, the target streams the telemetry data specified by the sensor-group subscription to the collector. In contrast, the gRPC network management interface (gNMI) dial-in method that requires the collector to initiate a connection to the target device.

The gRPC dial-out method simplifies the streaming of telemetry statistics. Configuring the target device to stream statistics and export them to a collector IP address removes the burden of access being placed on the collector (client).

Junos Telemetry supports dial-out connections over UDP in Protobuf Compact Format (Juniper Proprietary) and Protobuf Structured Format. It also supports dial-out connections over TCP in Protobuf Structured Format. Starting with Junos OS Release 25.4R1, you can configure the dial-out type using the CLI option *export-profile (Junos Telemetry Interface)* at the `[edit services analytics export-profile name]` hierarchy.

Figure 4: Dial-Out Mechanism



Benefits of Using Dial-Out Telemetry

- Reduces target device exposure to threats outside the topology.
- Simplifies access to a target device. The dial-in method requires a collector to complete a series of complex firewall configurations to access the target device. Where as, the dial-out mechanism does not have such requirements.
- Collectors can be stateless. They do not need to initiate a session, and they simply listen, subscribe, and store collected data.
- Supports mutual encryption for heightened security.

Streaming Telemetry Data Over UDP

SUMMARY

This section describes streaming telemetry data over a UDP connection.

IN THIS SECTION

UDP-based telemetry streaming uses a dial-out mechanism, where the device sends telemetry data to a configured collector. The sensor paths are configured through CLI and the device sends the data for the configured sensor paths over a UDP connection to the destination address of the collector. The destination address is also configured through the CLI.

Junos Telemetry supports two formats of telemetry data for UDP streaming:

- Dial-out over UDP (Protobuf Compact Format, Juniper Proprietary)
- Dial-out over UDP (Protobuf Structured Format) *jnx_gnmi_over_udp.proto* file

Both formats differ in structure and decoding requirements.

Dial-out over UDP (Protobuf Compact Format, Juniper Proprietary)

The device streams telemetry data from native sensors to the collector over UDP in the *protobuf* format. For *protobuf* format information, see "Protobuf Compact Message Format (Juniper Proprietary) " on page 12.

The collector decodes the telemetry data using using Junos-specific utilities and protocol buffers files. See, Decoding Junos Telemetry Data With UNIX Utilities.

Dial-out over UDP (Protobuf Structured Format)

The device streams telemetry data encoded in the `UdpTelemetryUpdate` message from the sensors to the collector over UDP. The message format is defined in the `jnx_gnmi_over_udp.proto` file. Only `STREAM` mode with `SAMPLE` as subscription mode is supported. The message contains full key name and value pair information so the collector does not require data models for processing or consuming the telemetry data.

Sample message containing complete key name and value pair information:

```
update {

   timestamp: 1730130393137318248

   prefix: /interfaces/interface[name='et-1/0/13']/state/counters

update {
```

```
    path {
       elem {
          name:   in-pkts
       }
    }
    val {
      uint_val: 0
       }
    }
update {
    path {
       elem {
          name:   in-octets
       }
    }
    val {
      uint_val: 0
       }
    }
}
```

For complete list of resource paths supported, see Junos YANG Data Model Explorer.

Configure Telemetry Data Streaming over UDP

To configure telemetry data streaming over UDP, configure a sensor profile, a streaming server profile, and an export profile, see "Establish a Dial-out Telemetry Connection" on page 94.

Configure gRPC service for Dial-out over TCP Connections

SUMMARY

Dial-out over TCP connections use the outgoing interface IP address as the source address. Starting from release 24.2, you can configure a source IP address and a routing instance for dial-out over TCP connections. This section describes the procedures for configuring the source IP address and routing instance for dial-out over TCP connections.

IN THIS SECTION

Configure an IP Source Address for Dial-out over TCP Connections

Starting from Junos OS Evolved Release 24.2R1, Junos Telemetry supports configuring a source IP address for dial-out over TCP connections on ACX Series routers, PTX Series routers, and QFX Series switches. In earlier releases that dial-out over TCP connections, the outgoing interface IP address is used as the source address without an option to configure a source IP address. This feature supports FLEX Deployments, providing the ability to send dial-out from the router's specified IP address or interface address (such as a loopback0 address).

If you do not configure a local address, the default local address is used.

NOTE: Starting with Junos OS release 25.4R1, the `format` and `transport` options are deprecated. Use the CLI option `dialout-type` at the `[edit services analytics export-profile name]` hierarchy to specify the type of dial-out connection. Select the option `native-grpc-gpb` for `gpb-gnmi` message format.

To configure a local address:

1. In configuration mode, go to the `[edit services analytics export-profile]` hierarchy level and add the name of your export profile (here **ep1**).

```
user@host# edit services analytics export-profile ep1
```

2. Include the `local-address` statement (here, with IPv6 address **2000:200::20**).

   You can only use an IPv6 address for dial-out over TCP connections . IPv6 addresses are not supported by UDP transport.

```
[edit services analytics export-profile ep1]
user@host# set local-address 2000:200::20
```

3. Use the following operational mode command to confirm the local address configuration.

```
user@host> show services
```

```
analytics {
    streaming-server remote-dialout-server {
        remote-address 10.220.23.206;
        remote-port 50051;
    }
    export-profile ep1 {
        local-address 2000:200::20;--  IPv6 address configured
        reporting-rate 10;
        dialout-type native-grpc-gpb

    }
}
```

   The export file `ep1` shows the IPv6 address `2000:200::20` as the local address.

RELATED DOCUMENTATION

local-address (Junos Telemetry Interface)

Configure a Routing Instance for Dial-out over TCP Connections

Starting with Junos OS Evolved Release 24.2R1, Junos Telemetry supports configuring a routing instance for dial-out over TCP connections on ACX Series routers, PTX Series routers, and QFX Series switches.

If you do not configure a routing instance, the default routing instance is used.

> **NOTE**: Starting with Junos OS release 25.4R1, the `format` and `transport` options are deprecated. Use the CLI option `dialout-type` at the `[edit services analytics export-profile name]` hierarchy to specify the type of dial-out connection. Select the option `native-grpc-gpb` for `gpb-gnmi` message format .

To configure a routing instance:

1. In configuration mode, go to the `[edit services analytics export-profile]` hierarchy level and add the name of your export profile (here **ep1**).

   ```
   user@host# edit services analytics export-profile ep1
   ```

2. Include the `routing-instance` statement (here, with routing instance **mgmt-1**).

   You can only configure a routing instance for dial-out over TCP connections .

   ```
   [edit services analytics export-profile ep1]
   user@host# set routing-instance mgmt-1
   ```

3. Use the following operational mode command to confirm the routing instance configuration.

   ```
   user@host> show services
   ```

   ```
   show services
   analytics {
       streaming-server remote-dialout-server {
           remote-address 10.220.23.206;
           remote-port 50051;
       }
       export-profile ep1 {
           local-address 2000:200::20;
           reporting-rate 10;
           dialout-type native-grpc-gpb
   ```

```
        routing-instance mgmt-1;
    }
}
```

The export file `ep1` displays the routing instance as `mgmt-1`.

RELATED DOCUMENTATION

routing-instance (Junos Telemetry Interface)

Establish a Dial-out Telemetry Connection

SUMMARY

Use this procedure to establish a dial-out telemetry connection. Configure the gRPC service, streaming server profile, sensor profile, export profile, and data collector based on the sensor information you want to collect from the Junos device.

IN THIS SECTION

In dial-out mode, the Juniper device initiates a connection to an external telemetry collector and streams telemetry data. This method is preferred when centralized management of telemetry data is required, as the device pushes data to the collector without requiring the collector to initiate connections.

- Ensure that the Juniper device runs a compatible Junos OS version that supports Junos Telemetry.
- Set up a telemetry collector (for example, Juniper Telemetry Collector, Prometheus, or InfluxDB) compatible with the chosen transport protocol (UDP or TCP).

- Ensure that the network connectivity between the Juniper device and the collector (for example, TCP port 50051 for gRPC or a custom port for UDP).
- If using TLS with gRPC, prepare certificates for the device and collector.

> **NOTE**: Prior to release Junos OS 25.4R1, TLS options were configured under the `edit system services extension-service request-response grpc ssl` hierarchy. From Junos OS release 25.4R1 onwards, use the Public Key Infrastructure (PKI) commands to load local certificates and Certificate Authority (CA) profiles, see "Configure a Streaming Server Profile" on page 97.

- Refer to the Junos YANG Data Model Explorer (introduced in Junos OS Release 23.2R2-S2) or Junos Telemetry Sensor Explorer (for releases 20.2R1 to 23.1R1) for supported sensors.
- For dial-out over TCP connections configure the IP address and routing instance, see "Configure gRPC service for Dial-out over TCP Connections" on page 91.
- Types of Dial-out Telemetry:

  Junos Telemetry supports three types of dial-out connections. Each connection type uses a different message format and has specific decoding requirements. To configure the `dialout-type`, see "Configure an Export Profile" on page 102.

Table 7: Types of Dial-out Telemetry

Dial-out Type	Configure using the CLI Option	Message Format	Data Models	Decoding Requirements	Transport Protocol	Subscription Type
Dial-out over UDP (Protobuf Compact Format, Juniper Proprietary)	`native-udp-compact`	Sensor data in *protobuf (.gpb)* format. Protobuf messages are in compact form.	Junos native and OpenConfig models.	Uses Junos-specific utilities, *telemetry_top.proto*, and sensor proto files for decoding.	UDP	STREAM

Table 7: Types of Dial-out Telemetry *(Continued)*

Dial-out Type	Configure using the CLI Option	Message Format	Data Models	Decoding Requirements	Transport Protocol	Subscription Type
Dial-out over UDP (Protobuf Structured Format)	`native-udp-gpb`	Protobuf messages are in structured self-describing key-value pairs.	All data models	The message contains full key name and value pair information, so the collector does not require data models for processing or consuming the telemetry data. The message structure is defined in the *jnx_gnmi_over_udp.proto* file.	UDP	STREAM with SAMPLE mode
Dial-out over TCP (Protobuf Structured Format)	`native-grpc-gpb`	Protobuf messages are in structured universal key/value format.	All data models	Uses *gnmi.proto* and *GnmiJuniperTelemetryHeader.proto* for decoding.	TCP	STREAM

NOTE: From release 25.4, the `format` and `transport` options under the `[edit services analytics export-profile` *`name`*`]` heirarchy are deprecated.

- **Protobuf compact format:**

This format is considered "compact" as it does not contain verbose key-value representations. However, you must download the latest version of protobuf files to decode the telemetry data.

- **Protobuf structured format**:

  This format uses self-describing key-value pairs within Protobuf messages. Each message includes complete sensor data names and values, the can collectors process sensor data even without the data model files.

Configure a sensor to monitor a specific system resource. Each sensor configuration requires three main components:

- Streaming server profile—Specifies the server for collecting data and related parameters, including the destination IP address and port number. Before you begin, configure a connection from your Juniper Networks device to a server that is using in-band management interfaces.
- Sensor profile— Allows monitoring of the system resource and enables you to set related parameters, such as the destination server that is used to receive data.
- Export profile— Specifies attributes for exporting the collected data.

BEST PRACTICE: We recommend you configure at least one export profile and at least one streaming server before you configure a sensor profile. You can then associate an export profile and a streaming server with the sensor profile configuration.

To enable export of statistics, include the `export-profile` and `sensor` statements at the [`edit services analytics`] hierarchy level. The sensor configuration must include the collector's name, the export profile's name, and the resource path.

Resource path example: **/interfaces/interface[name='fxp0']**.

NOTE: When configuring an export profile for dial-out over UDP, the export profile parameters, such as {'dscp', 'forwarding-class', 'payload-size'} are not applicable. Configuring any of these options generates an error.

Follow the procedures listed below to establish a dial-out telemetry connection:

Configure a Streaming Server Profile

A server profile defines the parameters of the server that collects exported telemetry data. You can define more than one server profile. You can also associate the same server profile with more than one sensor profile. You can associate more than one server with a specific sensor.

NOTE: Guidelines for Streaming Telemetry Data Over UDP:

1. Telemetry data streams directly from the source application to the collector over UDP. The configuration depends on the type of connection to the collector. The collector must be reachable over the management interface or a WAN interface.

2. In the case of line card sensors, the line cards can directly export the data to the collector if the remote address is reachable over the WAN interface. If the telemetry data must be exported over the management interface for line card sensors, route the data to the Routing Engine and then send it to the collector.

To define the profile of a streaming server to collect exported telemetry data:

1. Specify the name of the streaming sever.

```
[edit services analytics]
user@host# set streaming-server server-name
```

   For example, to specify a streaming-server name of `telemetry-server`:

```
[edit services analytics]
user@host# set streaming-server telemetry-server
```

2. Specify a destination IP address for the exported packets.

```
[edit services analytics streaming-server server-name]
user@host# set remote-address ip-address
```

   For example, to specify a destination address of 192.0.2.2 for a streaming server with the name *telemetry-server*:

```
[edit services analytics streaming-server telemetry-server]
user@host# set remote-address 192.0.2.2
```

3. Specify a destination port number for the exported packets.

```
[edit services analytics streaming-server server-name]
user@host# set remote-port number
```

For example, to specify a destination port number of 30000 for a streaming server with the name *telemetry-server*:

```
[edit services analytics streaming-server telemetry-server]
user@host# set remote-port 30000
```

4. Specify the TLS parameters, local certificate-id, and ca-profile. You can configure the TLS parameters for each streaming server. For dialout connections you must configure the TLS parameters for each streaming server.

```
[edit services analytics streaming-server server-name]
user@host# set tls
```

```
[edit services analytics streaming-server server-name tls]
user@host# set certificate-id local-cert-id
```

```
[edit services analytics streaming-server server-name tls]
user@host# set ca-profiles ca-profiles
```

NOTE: TLS is not applicable to UDP.

NOTE: Prior to release 25.4, TLS options were configured under the `edit system services extension-service request-response grpc ssl` hierarchy. This configuration method is no longer supported starting with release 25.4.

NOTE: From release 25.4 onwards, use the following Public Key Infrastructure (PKI) commands to load local certificates and Certificate Authority (CA) profiles:

- `request security pki local-certificate load certificate-id` *`certificate id`* `filename` *`dialout_client.crt`* `key` *`dialout_client.key`*
- `request security pki ca-certificate load ca-profile` *`ca-profile-name`* `filename` *`path/filename`*

Configure a Sensor Profile

A sensor profile defines the parameters of the system resource to monitor and stream data. You can enable only one system resource to monitor for each sensor profile. Configure a different sensor profile for each system resource you want to monitor. You can, however, configure more than one sensor to monitor the same system resource. For example, consider configuring different parameters for exporting data from the same system resource.

To configure a sensor profile:

1. Specify the name of the sensor.

   ```
   [edit services analytics]
   user@host# set sensor sensor-name
   ```

   For example, to specify a sensor name of `interface-1`:

   ```
   [edit services analytics]
   user@host# set sensor interface-1
   ```

2. Specify the system resource to monitor and stream data.

   ```
   [edit services analytics sensor sensor-name]
   user@host# set resource resource-string-identifier
   ```

   For example, to enable monitoring of logical interfaces for sensor `interface-1`:

   ```
   [edit services analytics sensor interface-1]
   user@host# set resource /junos/system/linecard/interface/logical/usage/
   ```

   NOTE: You must enter the resource string exactly.

3. (Optional) Specify a regular expression to filter data for the system resource you specified in Step 2. If you do not specify a regular expression, the system resource is monitored globally, that is, systemwide.

   ```
   [edit services analytics sensor sensor-name]
   user@host# set resource-filter regular-expression
   ```

For example, to filter data only for Ethernet logical interfaces for sensor `interface-1`:

```
[edit services analytics sensor interface-1]
user@host# set resource-filter et-*
```

4. Specify the name of a export profile configured at the `[edit export-profile *profile-name*]` hierarchy level to associate with the sensor profile. This export profile defines the parameters for exporting telemetry data.

```
[edit services analytics sensor sensor-name]
user@host# set export-name export-profile-name
```

For example, to associate an export profile named `export-params` with a sensor named `interface-1`:

```
[edit services analytics sensor interface-1]
user@host# set export-name export-params
```

5. Specify the name of a streaming server name configured at the `[edit services analytics streaming-server *server-name*]` hierarchy level to collect exported data.

NOTE: You can specify more than one streaming server for a sensor profile. To specify more than one streaming server for a sensor, you must enclose the names in brackets.

```
[edit services analytics sensor sensor-name]
user@host# set streaming-server server-name
```

For example, to associate a streaming server name `telemetry-server` with a sensor named `interface-1`:

```
[edt services analytics sensor interface-1]
user@host# set streaming-server telemetry-server
```

Configure an Export Profile

IN THIS SECTION

An export profile defines the parameters of the export process of data generated through the Junos Telemetry mechanism. You must configure at least one export profile, you can also configure multiple export profiles. Each export profile can be associated with multiple sensor profiles. However, you can associate only one export profile with a specific sensor profile.

Platform-Specific Export Profile Behavior

Use Feature Explorer to confirm platform and release support for specific features.

Use the following table to review platform-specific behaviors for your platforms:

Table 8: Platform-Specific Export Profile Behavior

Platform	Difference
MX Series	On MX Series routers you can specify a packet loss priority for an export profile. As a result, you can apply the appropriate packet loss priority to each sensor. Loss priority settings help determine which packets are dropped from the network during periods of congestion. Previously, you could specify only the forwarding class and the DSCP value in an export profile. The following packet loss priority settings are supported: `high`, `low`, `medium-high` and `medium-low`. For more information about packet loss priority settings, see Mapping PLP to RED Drop Profiles.

To configure an export profile:

1. Specify a name for the export profile.

```
[edit services analytics]
user@host# set export-profile name
```

For example, to specify an export-profile name of `export-params`:

```
[edit services analytics]
user@host# set export-profile export-params
```

2. Specify the source IP address of exported packets.

```
[edit services analytics export-profile name]
user@host# set local-address ip-address
```

For example, to specify a source IP address of 192.0.2.3 for an export profile with the name `export-params`:

```
[edit services analytics export-profile export-params]
user@host# set local-address 192.0.2.3
```

3. Specify the source port number of exported packets.

```
[edit services analytics export-profile name]
user@host# set local-port number
```

For example, to specify a source port number of 21111 for an export profile with the name `export-params`:

```
[edit services analytics export-profile export-params]
user@host# set local-port 21111
```

4. Specify the interval, in seconds, at which the sensor generates telemetry data.

```
[edit services analytics export-profile name]
user@host# set reporting-rate seconds
```

- At the end of each configured interval, the sensor gathers the most recent sample and forwards it to the designated data collection server.
- Valid range: For releases prior to 23.4 R2, 1 to 86400 seconds (24 hours).

> **NOTE**: Starting with Junos OS and Junos Evolved 23.4R2, the minimum supported value for `reporting-rate` is *"2"* seconds for Packet Forwarding Engine (PFE) sensors. If a configuration specifies a value below *"2"* seconds and a software upgrade is performed, the configuration will be dropped, and telemetry will not be operational until the value is corrected.

For example, to specify an interval of 20 seconds at which any sensor associated with the export-profile with the name `export-params` generates telemetry data :

```
[edit services analytics sensor export-profile export-params]
user@host# set reporting-rate 20
```

5. Specify the type of dial-out connection.

```
[edit services analytics export-profile name]
user@host# set dialout-type (native-udp-gpb | native-udp-compact | native-grpc-gpb)
```

- `native-udp-gpb`: Select this option for dial-out over UDP (Protobuf Structured Format) connections. The message format is protobuf messages with structured self-describing key-value pairs and the transport protocol is UDP.
- `native-udp-compact`: Select this option for dial-out over UDP (Protobuf Compact Format, Juniper Proprietary) connections. The message format is .gpb and the transport protocol is UDP.
- `native-grpc-gpb`: Select this option for dial-out over TCP (Protobuf Structured Format) connections. The message format is gpb-gnmi (protobuf messages in structured universal key/value format) and the transport protocol is TCP.

For example, to stream native sensor information over UDP:

```
[edit services analytics sensor export-profile export-params]
user@host# set dialout-type native-udp-compact
```

> **NOTE**: From release 25.4, the `format` and `transport` options are deprecated.

6. (Optional) Specify the DiffServ code point (DSCP) value to assign to exported packets.

   NOTE: The default value is `0` (zero).

   Any interface-level DSCP rewrite rules you have configured override the DSCP value you specify for the export profile. Specify a DSCP value for the export profile only if you do not configure DSCP rewrite rules on the outgoing interface. For more information, see *Configuring Rewrite Rules*.

   ```
   [edit services analytics export-profile name]
   user@host# set dscp value
   ```

   For example, to specify a DSCP value of 20 for an export profile with the name `export-params`:

   ```
   [edit services analytics export-profile export-params]
   user@host# set dscp 20
   ```

7. (Optional) Specify a forwarding class to assign to exported packets.

   NOTE: You can specify a forwarding class only for packets exported by Packet Forwarding Engine sensors. The default value is `best-effort`.

   ```
   [edit services analytics export-profile name]
   user@host# set forwarding-class class-name
   ```

   For example, to specify a forwarding class of `assured-forwarding` for an export-profile with the name `export-params`:

   ```
   [edit services analytics export-profile export-params]
   user@host# set forwarding-class assured forwarding
   ```

8. (Optional) (Only on MX Series routers) Specify a packet loss priority to assign to exported packets.

   ```
   [edit services analytics export-profile name]
   user@host# set loss-priority (low | high | medium-low | medium-high)
   ```

For example, to specify a loss priority of `high` for an export profile with the name `export-params`:

```
[edit services analytics export-profile export-params]
user@host# set loss-priority high
```

Configure the Data Collector

1. Ensure that the collector is ready to receive data from the Juniper device:
   - IP Address: The device's management IP address (192.168.1.100).
   - Port: The configured port (for example, 2000 for UDP, 50051 for gRPC).
   - Protocol: Select the transport protocol (for example, UDP or gRPC).
   - Credentials: If TLS is enabled, configure the collector with the appropriate client certificate and key.
   - Data format: Ensure the collector supports Google Protocol Buffers (gpb) and has the necessary protobuf definitions to decode sensor data.

   Example collector configuration (for a UDP-based collector):

   Configure the collector to listen on `192.168.1.100:2000` and process `gpb-encoded` data.
2. On the data collector, verify if the data is received. For example, if Prometheus or Grafana is used as a data collector, check the logs or visualizations. For custom collectors, verify the data stream matches the configured sensor paths.
3. To decode Junos Telemetry Data, see Decoding Junos Telemetry Data With UNIX Utilities.

Verify the Junos Telemetry Interface Sensor Configuration

IN THIS SECTION

Purpose

Confirm your configuration.

Action

From configuration mode, confirm your configuration by entering the `show services analytics` command. If your output does not display the intended configuration, repeat the instructions in the configuration procedure to correct it.

After you commit the configuration, verify that the sensor is enabled by issuing the `show agent sensors` operational command.

> **NOTE**: The `show agent sensors` command output for gRPC sensors is truncated on the Junos OS Evolved platform to align with the output format of the Junos OS platform.

Selecting Sensor Paths

IN THIS SECTION

Sensor Explorer and Guidelines for Selecting Sensor Paths

Use the Juniper Networks Junos YANG Data Model Explorer to view all the supported resource paths, their corresponding leaves, and the device platforms that support them.

> **NOTE**: The Junos YANG Data Model Explorer was introduced in the 23.2R2-S2 releases. From releases 20.2R1 up to 23.1R1, the sensor information is available in the Junos Telemetry Sensor Explorer.

To search and view other telemetry sensors and specific information about some legacy sensors, see "Legacy Sensor Paths" on page 260.

For information on guidelines and best practices for configuring sensor paths, see "Explore Sensor Paths" on page 9.

Decoding Junos Telemetry Interface Data With UNIX Utilities

SUMMARY

You can use UNIX utilities to decode Junos telemetry interface data on a server, or collector, that is streaming data from a Juniper Networks device. The example in this section shows you how to decode a single packet of streamed data.

IN THIS SECTION

Preparing the Collector to Decode Data

This example requires the following:

- UNIX OS with the Netcat (nc) utility.
- Protocol buffers compiler.
- Junos telemetry interface protocol buffer files.

This procedure shows how to prepare the collector to decode data using the Ubuntu OS.

1. Install the Netcat utility.

```
sudo apt-get install netcat
```

2. Install the protocol buffers compiler.

```
sudo apt-get install protobuf-compiler
```

3. Install the protocol buffers developer's library.

```
sudo apt-get install libprotobuf-dev
```

4. Verify that the library files are installed.

```
ls /usr/include/google/protobuf/descriptor.proto
/usr/include/google/protobuf/descriptor.proto
```

5. Download and install the latest version of the Junos Telemetry interface protocol buffers files.

   From a web browser, navigate to the All Junos Platforms software download URL on the Juniper Networks page: https://www.juniper.net/support/downloads/. After you select the name of the Junos OS platform and the release number, go to the **Tools** section and download the **Junos telemetry interface Data Model Files** package.

   NOTE: Juniper Networks publishes YANG modules for Junos devices, which can be downloaded from the Juniper GitHub repository. From release 23.4 onwards configuration and telemetry YANG models are merged and published in the Juniper GitHub repository. This contains YANG definitions for configuration, RPCs and telemetry models.

   NOTE: Ensure that you make a note of the location of the extracted files.

Decoding Data on the Collector

This procedure shows you how to capture data, decode raw data, and use the protocol buffers files to decode data.

To decode data:

1. Capture the data.

   Run netcat on a destination streaming telemetry server, or collector, in UDP listener mode to store all incoming datagrams into a file. Use the destination port number configured in streaming-server profile on your Juniper Networks device.

```
nc -ul 0.0.0.0 20000 > data.gpb
```

   NOTE: This command stores datagrams into a file named `data.gpb`. Run this program to capture data. When you want to stop receiving data, stop with the program by sending the break signal (`Control + C`)

2. Decode raw data.

   NOTE: This step is optional. It is not required if you know the encoded message type of the data.

   Decoding requirements vary based on the configured `dial-out` type.

   - Dial-out over UDP (Protobuf Compact Format, Juniper Proprietary): Use Junos-specific utilities, *telemetry_top.proto*, and sensor proto files for decoding.
   - Dial-out over UDP (Protobuf Structured Format): The message contains full key name and value pair information, so the collector does not require data models for processing or consuming the telemetry data. The message structure is defined in the *jnx_gnmi_over_udp.proto* file.
   - Dial-out over TCP (Protobuf Structured Format): Use *gnmi.proto* and *GnmiJuniperTelemetryHeader.proto* files for decoding.

   The following example depicts how to decode the message from the `data.gpb` file for dial-out over UDP (Protobuf Compact Format, Juniper Proprietary) connections:

```
protoc --decode_raw  < ../data.gpb
1: "hillrock:160.1.1.25"
2: 0
4: "S1:/junos/system/linecard/interface/logical/usage/:/junos/system/linecard/interface/
logical/usage/:PFE"
5: 65265
6: 1477686534474
7: 1
8: 1
101 {
  2636 {
    7 {
      1 {
        1: "et-0/0/4:2.32767"
        2: 1477642750
        3: 813
        4 {
          12: 0x37363732332e3165
        }

.
```

```
.
.
```

The next nested structure under `2636` identifies the sensor type. The numerical value `2636` identifies the `JuniperNetworksSensor` message, which is defined in the `telemetry_top.proto` file. In this example, the numerical identifier `7` corresponds to the `LogicalPort` message defined in the `logical_port.proto` file. Use this information in the next step to generate more detailed output.

3. Decode the message to include field names.

   Run the protocol buffers compiler with the decode option. Additionally, specify the top-level message type (`TelemetryStream`) and the file with the message definition, `logical_port.proto`. You must also include the Goggle protocol buffers (gpb) library.

```
protoc --decode TelemetryStream logical_port.proto -I /usr/include -I .  < data.gpb
system_id: "hillrock:160.1.1.25"
component_id: 0
sensor_name: "S1:/junos/system/linecard/interface/logical/usage/:/junos/system/linecard/
interface/logical/usage/:PFE"
sequence_number: 65268
timestamp: 1477686536484
version_major: 1
version_minor: 1
enterprise {
  [juniperNetworks] {
    [jnprLogicalInterfaceExt] {
      interface_info {
        if_name: "et-0/0/4:2.32767"
        init_time: 1477642750
        snmp_if_index: 813
        parent_ae_name: "ae1.32767"
        ingress_stats {
          if_packets: 0
          if_octets: 0
        }
        egress_stats {
          if_packets: 0
          if_octets: 0
        }
        op_state {
          operational_status: "up"
        }
      }
```

```
        interface_info {
          if_name: "et-0/0/7:3.0"
          init_time: 1477642750
          snmp_if_index: 520
          parent_ae_name: "ae0.0"
          ingress_stats {
            if_packets: 61203309
            if_octets: 6487548454
          }
          egress_stats {
            if_packets: 87416547
            if_octets: 9266153982
          }
          op_state {
            operational_status: "up"
          }
        }
        interface_info {
          if_name: "et-0/0/13:0.0"
          init_time: 1477642750
          snmp_if_index: 2512
          ingress_stats {
            if_packets: 26266247
            if_octets: 2784214806
          }
          egress_stats {
            if_packets: 26247215
            if_octets: 2781829290
          }
          op_state {
            operational_status: "up"
          }
        }
        interface_info {
          if_name: "et-0/0/13:0.1"
          init_time: 1477642750
          snmp_if_index: 2522
          ingress_stats {
            if_packets: 26266249
            if_octets: 2784214972
          }
          egress_stats {
            if_packets: 26249115
```

```
      if_octets: 2781935590
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.2"
    init_time: 1477642750
    snmp_if_index: 2523
    ingress_stats {
      if_packets: 26266248
      if_octets: 2784214912
    }
    egress_stats {
      if_packets: 26249106
      if_octets: 2781935086
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.3"
    init_time: 1477642750
    snmp_if_index: 2524
    ingress_stats {
      if_packets: 26266248
      if_octets: 2784214820
    }
    egress_stats {
      if_packets: 26248520
      if_octets: 2781902320
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.4"
    init_time: 1477642750
    snmp_if_index: 2525
    ingress_stats {
```

```
        if_packets: 26266247
        if_octets: 2784214760
      }
      egress_stats {
        if_packets: 26247302
        if_octets: 2781834112
      }
      op_state {
        operational_status: "up"
      }
    }
    interface_info {
      if_name: "et-0/0/13:0.5"
      init_time: 1477642750
      snmp_if_index: 2526
      ingress_stats {
        if_packets: 26266247
        if_octets: 2784214760
      }
      egress_stats {
        if_packets: 26247209
        if_octets: 2781828904
      }
      op_state {
        operational_status: "up"
      }
    }
    interface_info {
      if_name: "et-0/0/13:0.6"
      init_time: 1477642750
      snmp_if_index: 2527
      ingress_stats {
        if_packets: 26266248
        if_octets: 2784214820
      }
      egress_stats {
        if_packets: 26247196
        if_octets: 2781828226
      }
      op_state {
        operational_status: "up"
      }
    }
```

```
        interface_info {
          if_name: "et-0/0/13:0.7"
          init_time: 1477642750
          snmp_if_index: 2528
          ingress_stats {
            if_packets: 26266247
            if_octets: 2784214760
          }
          egress_stats {
            if_packets: 26247203
            if_octets: 2781828618
          }
          op_state {
            operational_status: "up"
          }
        }
        interface_info {
          if_name: "et-0/0/13:0.8"
          init_time: 1477642750
          snmp_if_index: 2529
          ingress_stats {
            if_packets: 26266247
            if_octets: 2784214760
          }
          egress_stats {
            if_packets: 26247225
            if_octets: 2781829850
          }
          op_state {
            operational_status: "up"
          }
        }
        interface_info {
          if_name: "et-0/0/13:0.9"
          init_time: 1477642750
          snmp_if_index: 2530
          ingress_stats {
            if_packets: 26266247
            if_octets: 2784214760
          }
          egress_stats {
            if_packets: 26247209
            if_octets: 2781828954
```

```
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.32767"
    init_time: 1477642750
    snmp_if_index: 648
    ingress_stats {
      if_packets: 4
      if_octets: 240
    }
    egress_stats {
      if_packets: 0
      if_octets: 0
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/4:2.32767"
    init_time: 1477642750
    snmp_if_index: 813
    parent_ae_name: "ae1.32767"
    ingress_stats {
      if_packets: 0
      if_octets: 0
    }
    egress_stats {
      if_packets: 0
      if_octets: 0
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/7:3.0"
    init_time: 1477642750
    snmp_if_index: 520
    parent_ae_name: "ae0.0"
```

```
    ingress_stats {
      if_packets: 61206122
      if_octets: 6487846632
    }
    egress_stats {
      if_packets: 87420567
      if_octets: 9266580102
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.0"
    init_time: 1477642750
    snmp_if_index: 2512
    ingress_stats {
      if_packets: 26267458
      if_octets: 2784343172
    }
    egress_stats {
      if_packets: 26248420
      if_octets: 2781957020
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.1"
    init_time: 1477642750
    snmp_if_index: 2522
    ingress_stats {
      if_packets: 26267460
      if_octets: 2784343338
    }
    egress_stats {
      if_packets: 26250320
      if_octets: 2782063320
    }
    op_state {
      operational_status: "up"
    }
```

```
      }
      interface_info {
        if_name: "et-0/0/13:0.2"
        init_time: 1477642750
        snmp_if_index: 2523
        ingress_stats {
          if_packets: 26267459
          if_octets: 2784343278
        }
        egress_stats {
          if_packets: 26250311
          if_octets: 2782062816
        }
        op_state {
          operational_status: "up"
        }
      }
      interface_info {
        if_name: "et-0/0/13:0.3"
        init_time: 1477642750
        snmp_if_index: 2524
        ingress_stats {
          if_packets: 26267460
          if_octets: 2784343292
        }
        egress_stats {
          if_packets: 26249725
          if_octets: 2782030050
        }
        op_state {
          operational_status: "up"
        }
      }
      interface_info {
        if_name: "et-0/0/13:0.4"
        init_time: 1477642750
        snmp_if_index: 2525
        ingress_stats {
          if_packets: 26267459
          if_octets: 2784343232
        }
        egress_stats {
          if_packets: 26248507
```

```
        if_octets: 2781961842
      }
      op_state {
        operational_status: "up"
      }
    }
    interface_info {
      if_name: "et-0/0/13:0.5"
      init_time: 1477642750
      snmp_if_index: 2526
      ingress_stats {
        if_packets: 26267459
        if_octets: 2784343232
      }
      egress_stats {
        if_packets: 26248414
        if_octets: 2781956634
      }
      op_state {
        operational_status: "up"
      }
    }
    interface_info {
      if_name: "et-0/0/13:0.6"
      init_time: 1477642750
      snmp_if_index: 2527
      ingress_stats {
        if_packets: 26267460
        if_octets: 2784343292
      }
      egress_stats {
        if_packets: 26248401
        if_octets: 2781955956
      }
      op_state {
        operational_status: "up"
      }
    }
    interface_info {
      if_name: "et-0/0/13:0.7"
      init_time: 1477642750
      snmp_if_index: 2528
      ingress_stats {
```

```
      if_packets: 26267459
      if_octets: 2784343232
    }
    egress_stats {
      if_packets: 26248408
      if_octets: 2781956348
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.8"
    init_time: 1477642750
    snmp_if_index: 2529
    ingress_stats {
      if_packets: 26267459
      if_octets: 2784343232
    }
    egress_stats {
      if_packets: 26248430
      if_octets: 2781957580
    }
    op_state {
      operational_status: "up"
    }
  }
  interface_info {
    if_name: "et-0/0/13:0.9"
    init_time: 1477642750
    snmp_if_index: 2530
    ingress_stats {
      if_packets: 26267459
      if_octets: 2784343232
    }
    egress_stats {
      if_packets: 26248414
      if_octets: 2781956684
    }
    op_state {
      operational_status: "up"
    }
  }
```

```
        interface_info {
          if_name: "et-0/0/13:0.32767"
          init_time: 1477642750
          snmp_if_index: 648
          ingress_stats {
            if_packets: 4
            if_octets: 240
          }
          egress_stats {
            if_packets: 0
            if_octets: 0
          }
          op_state {
            operational_status: "up"
          }
        }
      }
    }
  }
```

Decoding Junos Telemetry Interface UDP Data at the Collector

The collector must start a listener on the remote address or port combination to read the incoming data. For dial-out over UDP (Protobuf Compact Format, Juniper Proprietary) connections, the incoming data can be decoded using the *telemetry_top.proto* and the sensor proto files. For dial-out over UDP (Protobuf Structured Format) connections, the message contains full key name and value pair information, so the collector does not require data models for processing or consuming the telemetry data. The message structure is defined in the *jnx_gnmi_over_udp.proto file*.

To simplify the decoding procedure, the collectors can load all the proto files shipped as part of the Telemetry Software package to decode the incoming data.

NOTE:

1. Verify streaming data on both management and WAN interfaces. Specify the appropriate address in the streaming server profile.

2. Enums and float are streamed as strings for UDP streaming. Enums will be retained as strings as gNMI uses the same format.

3. The handling of float data type is scoped for a future release.

When telemetry data is streamed over UDP, ensure that data is decoded correctly, and unknown fields are not decoded at the collector.

Some of the issues observed while streaming telemetry data over UDP are as follows:

1. **Incorrect Decoding**: Incorrect decoding implies that telemetry data is not correctly streamed over UDP. In the following example, the data highlighted in bold indicates that the data was not decoded correctly. This behaviour is either due to incorrect encoding or wrong proto file packaging.

```
system_id: "r02.dtw01.icn"
component_id: 65535
sensor_name: "mpls:/network-instances/network-instance/mpls:/network-instances/network-
instance/mpls:rpd"
sequence_number: 2421 timestamp: 1715024560793
version_major: 1 version_minor: 0 enterprise: { [juniperNetworks]:
{   [jnpr_network_instances_rsvp_ext]: {
   network_instance: { name: "master" mpls: { 153 { 151
{         152{     151{     51: "r02.dtw01.icn-r01.bos02.icn-01"
        152{     151{    51: "AUTO"
         52: 0
         53: 12873154
        }     152{
         151{
         51:1
         52:200000
         53: 0
         54: 300
         55: 1

         61: 1549061
        }          152 {
```

The example of correctly decoded data is as follows:

```
system_id: "r0-RE0"
component_id: 65535
sub_component_id: 0
```

```
sensor_name: "test_chassisd:/network-instances/:/network-instances/:rpd"
sequence_number: 0
timestamp: 1719126223900
version_major: 1
version_minor: 0
enterprise {
  [juniperNetworks] {
    [jnpr_network_instances_ni_226_ext] {
      network_instance {
        name: "DEFAULT"
        protocols {
          protocol {
          identifier: "STATIC"
          name: "DEFAULT"
          static_routes {
            static {
            prefix: "10.0.0.0/8"
            state {
              prefix: "10.0.0.0/8"
              set_tag: "0"
            }
            next_hops {
              next_hop {
                index: "1"
                state {
                  index: "1"
                  next_hop: "10.220.127.254"
                  metric: 0
                  recurse: false
                }
                interface_ref {
                  state {
                    interface: "re0:mgmt-0"
                    subinterface: 0
                  }
                 }
                }
               }
              }
```

2. **Incomplete data streaming**: Streaming of incomplete data must be verified through data validation in the output file.

RELATED DOCUMENTATION

Configuring a Junos Telemetry Interface Sensor (CLI Procedure)

4

PART

Junos Telemetry Features

gRPC Tunnels Overview

IN THIS SECTION

A gRPC tunnel acts as a client-server protocol that dials out a session from the target to the TCP client through the default routing instance or configured routing instance. If you do not choose to configure a routing instance, the gRPC tunnel uses the default routing instance.

You can configure the source address for each gRPC tunnel session to dial out a connection to the tunnel server. If you do not configure the source address, the kernel selects the source address that can reach the tunnel server.

For more information about gRPC tunnels, see https://github.com/openconfig/grpctunnel.

A gRPC tunnel has three main entities:

- Target—Represents the network device. The target is a gRPC client.
- Tunnel Server—A software entity that is an off-box application that manages the subscription and target registrations. The tunnel server is a gRPC server.
- Tunnel Client—A software entity that performs client tasks. The tunnel client may be self-contained within the tunnel server. The tunnel client is also a gRPC client.

Benefits of using a gRPC tunnel session:

- Overcomes a series of complex firewall configurations as the connection is established from the server side.
- Access various TCP server applications such as gNMI-gNOI, SSH, or NETCONF-SSH without any operational requirements.

gRPC Tunnel Architecture

A gRPC tunnel is a generic infrastructure for TCP-based applications to communicate within gRPC messages.

In general, the TCP client initiates a connection to the TCP server or target. Junos devices act as target that runs TCP server applications such as gNMI-gNOI, SSH, and NETCONF-SSH. If a client is unable to reach the server, common reasons could be:

- The server runs into complex firewall configurations with firewalls preventing inbound connections.
- The server runs into a router implementing network address translation (NAT).
- The server comes across any other operational requirements, which prevents outside connections.

When a TCP client is not able to reach a target, you can configure a gRPC tunnel session to establish a connection between the TCP client and the target. A gRPC tunnel session establishes a connection in the reverse direction where a target dials out to a TCP client.

To use a gRPC tunnel session, a tunnel client is added to the target-side where the grpc-tunnel process runs and all the gRPC tunnel-related configurations are performed. On the TCP client-side, a tunnel server is added.

You must include the `grpc-tunnel` configuration statement in the `[edit system services]` hierarchy to configure a gRPC tunnel session.

gRPC Tunnel Security

The gRPC tunnel is a dial-out model where a device initiates a connection based on the configuration. The gRPC tunnel is on a secure gRPC channel that uses TLS certificates.

Example: Configure a gRPC Tunnel

IN THIS SECTION

Overview

This section covers the steps needed to configure the target for this example. The target is the Junos OS device that includes the gRPC tunnel configuration.

Requirements

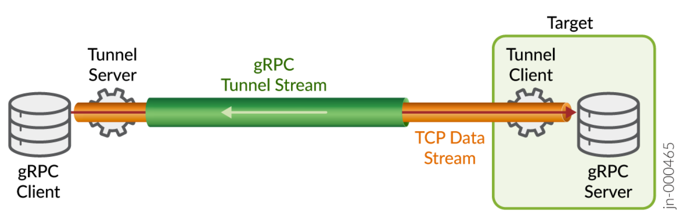
This example uses the following software and hardware components:

- Junos OS or Junos Evolved Release 22.4 or later for routing and switching devices
- One host device as the tunnel client
- One host device as the tunnel server

Topology

Figure 1 on page 128 shows the topology used in this example.

Figure 5: gRPC tunnel setup



Based on the Junos configuration of the target device, it dials-out a grpc-tunnel to the tunnel server. The target device registers itself with the tunnel server through the Register stream RPC.

When a client requests a TCP session to a specific target, the tunnel server acts as an intermediary and connects to the above registered target session on tunnel server.

If the target supports the requested type, the device dials out a new tunnel known as the Tunnel stream RPC. This procedure establishes a gRPC tunnel between the client and the target through the tunnel server. The tunnel client can now access the intended TCP applications on the target.

NOTE: Only one Register stream can exist between a tunnel server and a network device, but multiple Tunnel streams can exist for the same pair.

Configure a gRPC tunnel

IN THIS SECTION

CLI Quick Configuration

Configure this example by copying the following commands into a text file, adjusting network-specific details, then copying them into the CLI at the [edit] hierarchy level.

```
set system services grpc-tunnel servers server server1 address 10.205.0.1
set system services grpc-tunnel servers server server1 port 50301
set system services grpc-tunnel servers server server1 credentials tls certificate-id client-
cert1
set system services grpc-tunnel servers server server1 targets ssh
```

Step-by-Step Procedure

Follow these steps to configure the gRPC tunnel in the target device.

1. Configure the servers under gRPC-tunnel.

   a. Configure the IPv4 or IPv6 address or hostname of the tunnel server.

   ```
   [edit system services]
   user@host# set grpc-tunnel servers server server1 address 10.205.0.1
   ```

   b. Configure the port number through which the tunnel server listens.

   ```
   [edit system services]
   user@host# set grpc-tunnel servers server server1 port 50301
   ```

c. Configure the credentials using the **tls** statement.

```
[edit system services]
user@host# set grpc-tunnel servers server server1 credentials tls certificate-id client-
cert1
```

d. Specify the target applications you want to access. The options available are **ssh**, **netconf-ssh** and **gnmi-gnoi**.

```
[edit system services]
user@host# set grpc-tunnel servers server server1 targets ssh
```

2. (Optionally) Set the **retry-interval** (in seconds). If the tunnel-server is unreachable, the target device retries to connect after the retry-interval.

```
[edit system services]
user@host# set grpc-tunnel servers retry-interval 30
```

3. (Optionally)

   Set the **routing instance**. If you do not set the routing instance, the gRPC tunnel uses the default routing instance.

```
[edit system services]
user@host# set grpc-tunnel servers server ts1 routing-instance routing-instance
```

4. (Optionally)

   Set the **source address**. If you do not set the source address, the kernel picks the source address that can reach the tunnel server.

```
[edit system services]
user@host# set grpc-tunnel servers server ts1 source-address 69.70.31.677
```

5. (Optionally) Configure the **target-string-option** under **grpc-tunnel**.

a. Use the **pattern** statement to create an ordered list of supported options.

```
[edit system services]
user@host# set grpc-tunnel target-string-option pattern hostname custom
```

b. Use the **custom-string** statement to define a custom string that is sent when the statement **pattern** contains **custom** as one of the options.

```
[edit system services]
user@host# set grpc-tunnel target-string-option custom-string device1
```

c. Use the **delimiter** statement when more than one option is selected in the pattern. By default, the **|** (pipe symbol) is used.

```
[edit system services]
user@host# set grpc-tunnel target-string-option delimiter |
```

NOTE: A maximum of 10 tunnel servers can be configured.

Results

Display the results of the configuration on the target device. The output reflects only the functional configuration added in this example.

```
user@host> show configuration system services
```

```
grpc-tunnel {
    servers {
        retry-interval 30;
        server server1 {
            address 10.205.0.01;
            port 50301;
            credentials {
                tls {
                    certificate-id client-cert1;
```

```
                }
            }
            targets [ ssh ];
            routing-instance routing-instance;
            source-address 69.70.31.677;
        }
        server server2 {
            address 10.205.0.02;
            port 50302;
            credentials {
                tls {
                    ca-profiles [ serverRootCA1 serverRootCA2 ];
                }
            }
            targets [ gnmi-gnoi netconf-ssh ];
            routing-instance routing-instance;
            source-address 69.70.31.677;
        }
    }
    target-string-option {
        pattern [ hostname vendor model version custom ];
        custom-string device1;
        delimiter |;
    }
}
```

RELATED DOCUMENTATION

grpc-tunnel

Enabling Client Streaming and Bidirectional Streaming of Telemetry Sensor Information

Starting with Junos OS Release 18.1R1, OpenConfig support through Remote Procedure Calls (gRPC) and Junos Telemetry is extended to support client streaming and bidirectional streaming of telemetry sensor information on MX Series and PTX Series routers.

APIs are implemented in Junos based on Protobuf specifications for OpenConfig. These APIs provide configuration, operational state retrieval, and telemetry for devices running Junos routers using gRPC as the transport mechanism.

With client streaming, the client sends a stream of requests to the server instead of a single request. The server typically sends back a single response containing status details and optional trailing metadata. With bidirectional streaming, both client and server send a stream of requests and responses. The client starts the operation by invoking the RPC and the server receives the client metadata, method name, and deadline. The server can choose to send back its initial metadata or wait for the client to start sending requests. The client and server can read and write in any order. The streams operate completely independently.

Junos devices can be managed through API (RPC) prototypes:

- rpc Capabilities (CapabilityRequest)

  Returns (CapabilityResponse). Allows the client to retrieve the set of capabilities that the target supports.

- rpc Get (GetRequest)

  Returns (GetResponse). Retrieves a snapshot of data from the target.

- rpc Set (SetRequest)

  Returns (SetResponse). Allows the client to modify the state of data on the target.

- rpc Subscribe (stream SubscribeRequest)

  Returns (stream SubscribeResponse). Allows a client to request the target to send it values for particular paths within the data tree. These values may be streamed (STREAM) or sent one-off on a long-lived channel (POLL), or sent as a one-off retrieval (ONCE). If a subscription is made for a top-level container with a sample frequency of 0, leaves with ON_CHANGE support are streamed based on events. Other leaves will not be streamed.

Juniper Extension Toolkit (JET) support provides insight to users regarding the status of clients connected to JSD. JET support for gRPC includes expanding the maximum number of clients that can connect to JSD from 8 to 30 (the default remains 5). To specify the maximum number of connections, include the `max-connections` statement at the [`edit system services extension-service request-response grpc`] hierarchy level.

To provide information regarding the status of clients connected to JSD, issue the enhanced `show extension-service client information` command and include the `clients` or `servers` options. The `clients` option displays request-response client information. The `servers` option displays request-response server information.

Configure a NETCONF Proxy Telemetry Sensor in Junos

IN THIS SECTION

Using Junos telemetry streaming, you can turn any available state information into a telemetry sensor by means of the XML Proxy functionality. The NETCONF XML management protocol and Junos XML API fully document all options for every supported Junos OS operational request. After you configure XML proxy sensors, you can access data over NETCONF “get” remote procedure calls (RPCs).

This task shows you how to stream the output of a Junos OS operational mode command.

BEST PRACTICE: We recommend not to use YANG files that map to a Junos OS operational command with extensive or verbose output or one that is slow in producing output. Commands with a noticeable delay should be avoided in YANG files. Including such commands can affect other xmlproxyd sensors as well as the performance of xmlproxyd.
The output from some operational mode commands is dynamic and the level of their verbosity depends on factors such as the configuration and hardware. Examples of such commands include any variation of `show interfaces`, `show route`, `show arp`, `show bfd`, `show bgp`, and `show ddos-protection`.

To check the verbosity level of a command, issue the ***command-name*****| display xml |** **count** command. If the line count exceeds a value of 4000 lines, then the command is not recommended for XML proxy streaming. This value is more of an approximation based on internal base-lining. It can be less depending upon various factors such as device type, processing power of the device, and the existing CPU load. Consequently, this feature needs to be used judiciously based on how the device is performing.

You can issue the command ***command-name*| display xml** before using a YANG file that maps to a Junos OS or Junos OS Evolved operational mode command to verify that the command produces valid XML output and does not contain invalid tags, data, or formatting.

Using a YANG file that maps to a verbose command results in one or more of following:

- The xmlproxyd process CPU utilization remains high. If xmlproxyd has tracing enabled, the CPU utilization is even higher.
- An increase in the xmlproxyd process memory utilization.
- The xmlproxyd process state may show `sbwait`, indicating that the command output is verbose and that xmlproxyd is spending significant time reading the command's remote procedure call's (RPC's) output.
- The xmlproxyd sensor data does not complete the wrap.
- The xmlproxyd streams partial or no data for the sensors.
- The xmlproxyd misses reporting-interval cycles. The intervals start to overlap because of a command's verbose output, resulting in the xmlproxyd's sensor streaming data that is slow or delayed.
- The process or application that serves the verbose command's RPC may show high CPU numbers or delays in performing main tasks. This behavior is caused when the process or application is busy serving the RPC that has verbose output.

This task requires the following:

- An MX Series, vMX Series, or PTX Series router operating Junos OS Release 18.1R1 or later.
- A telemetry data receiver, such as OpenNTI, to verify proper operation of your telemetry sensor.

In this task, you will stream the contents of the Junos OS command `show system users`.

show system users (vMX Series)

```
user@switch> show system users
USER     TTY      FROM                              LOGIN@  IDLE WHAT
user1   pts/0       172.31.12.36                    12:40PM     39 -cli (cli)
user2   pts/1       172,16.03.25                     3:01AM      - -cli (cli)
```

In addition to the expected list of currently logged-in users, the `show system users` output also provides the average system load as 1, 5 and 15 minutes. You can find the load averages by using the `show system users`

| display xml command to view the XML tagging for the output fields. See <load-average-1>, <load-average-5>, and <load-average-15> in the XML tagging output below.

```
user@switch> show system users | display xml

<rpc-reply xmlns:junos="http://xml.juniper.net/junos/17.4R1/junos">
    <system-users-information xmlns="http://xml.juniper.net/junos/17.4R1/junos">
        <uptime-information>
            <date-time junos:seconds="1520170982">1:43PM</date-time>
            <up-time junos:seconds="86460">1 day, 40 mins</up-time>
            <active-user-count junos:format="2 users">2</active-user-count>
            <load-average-1>0.70</load-average-1>
            <load-average-5>0.58</load-average-5>
            <load-average-15>0.55</load-average-15>
            <user-table>
                <user-entry>
                    <user>root</user>
                    <tty>pts/0</tty>
                    <from>172.21.0.1</from>
                    <login-time junos:seconds="1520167202">12:40PM</login-time>
                    <idle-time junos:seconds="0">-</idle-time>
                    <command>cli</command>
                </user-entry>
                <user-entry>
                    <user>mwiget</user>
                    <tty>pts/1</tty>
                    <from>66.129.241.10</from>
                    <login-time junos:seconds="1520170862">1:41PM</login-time>
                    <idle-time junos:seconds="60">1</idle-time>
                    <command>cli</command>
                </user-entry>
            </user-table>
        </uptime-information>
    </system-users-information>
    <cli>
        <banner></banner>
    </cli>
</rpc-reply>
```

TIP: The `uptime-information` tag shown in the preceding output is a container that contains leafs, such as `date-time`, `up-time`, `active-user-count`. and `load-average-1`. Below is a sample YANG file for this container:

```
container uptime-information {
      dr:source "uptime-information"; // Exact name of the XML tag
      leaf date-time { // YANG model leaf
        type string; // Type of value
        dr:source date-time; // Exact name of the XML tag
      }
      leaf up-time { // YANG model leaf
        type string; // Type of value
        dr:source up-time; // Exact name of the XML tag
      }
      leaf active-user-count { // YANG model leaf
        type int32; // Type of value
        dr:source active-user-count; // Exact name of the XML tag
      }
      leaf load-average-1 { // YANG model leaf
        type string; // Type of value
        dr:source load-average-1; // Exact name of the XML tag
      }
      ...
```

TIP: The `uptime-information` tag also has another container named `user-table` that contains a list of user entries.

Below is a sample YANG file for this container:

```
container user-table { // "user-table" container which contains list of user-entry
        dr:source "user-table"; // Exact name of the XML tag
        list user-entry { // "user-entry" list which contains the users' details in form of leafs
          key "user"; // Key for the list "user-entry" which is a leaf in the list "user-entry"
          dr:source "user-entry"; // Source of the list "user-entry" which is the exact name of
the XML tag
          leaf user { // YANG model leaf
            dr:source user; // A leaf in the list "user-entry", exact name of the XML tag
            type string; // Type of value
          }
```

```
        leaf tty { // YANG model leaf
          dr:source tty; // A leaf in the list "user-entry", exact name of the XML tag
          type string; // Type of value
        }
        leaf from { // YANG model leaf
          dr:source from; // A leaf in the list "user-entry", exact name of the XML tag
          type string; // Type of value
        }
        leaf login-time { // YANG model leaf
          dr:source login-time; // A leaf in the list "user-entry", exact name of the XML tag
          type string; // Type of value
        }
        leaf idle-time { // YANG model leaf
          dr:source idle-time; // A leaf in the list "user-entry", exact name of the XML tag
          type string; // Type of value
        }
        leaf command { // YANG model leaf
          dr:source command; // A leaf in the list "user-entry", exact name of the XML tag
          type string; // Type of value
        }
      }
    }
```

Create a User-Defined YANG File

The YANG file defines the Junos CLI command to be executed, the resource path the sensors are placed under, and the key value pairs taken from the matching XML tags.

Custom YANG files for Junos OS conform to the YANG language syntax defined in RFC 6020 YANG 1.0 *YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)* and RFC 7950 *The YANG 1.1 Data Modeling Language*. Certain directives need to be present in the file that configure XML proxy.

To use the `xmlproxyd` process to translate telemetry data, create a `render.yang` file. In this file, the `dr:command-app` is set to `xmlproxyd`.

The XML proxy YANG filename and module name must start with `xmlproxyd_`:

- For the XML proxy YANG filename, add the extension `.yang`, for example, `xmlproxyd_sysusers.yang`

- For the module name, use the filename without the extension `.yang`, for example, `xmlproxyd_sysusers`

To simplify creating a YANG file, it's easiest to start by modifying a working example.

1. Provide a name for the module. The module name must start with `xmlproxyd_` and be the same name as the XML proxy YANG file name.

   For example, for an XML proxy YANG file called `sysusers.yang`, drop the `.yang` extension and name the module `xmlproxyd_sysusers`:

   ```
   module xmlproxyd_sysusers {
   ```
2. For the Junos telemetry interface include the process name `xmlproxyd`:

   ```
   dr:command-app "xmlproxyd";
   ```
3. Include the following RPC for the NETCONF get request:

   ```
   rpc juniper-netconf-get {
   ```
4. Specify the location of the output of the RPC, where *company-name* is the name you give to the location:

   ```
   dr:command-top-of-output "/company-name";
   ```
5. Include the following command to execute the RPC:

   ```
   dr:command-full-name "drend juniper-netconf-get";
   ```
6. Specify the CLI command from which to retrieve data. The Junos OS CLI command that gets executed at the requested sample frequency is defined under `dr:cli-command` and executed by the `xmlproxyd` process.

   To retrieve command output for the Junos OS command `show system users`:

   ```
   dr:cli-command "show system users";
   ```
7. Escalate privileges, logon as “root”, connect to the internal management socket via Telnet, and specify help for an RPC:

   ```
   dr: command-help “default <get> rpc”;
   ```

   When this is included in the YANG file, output that is helpful for debugging is displayed in the `help drend` output on the internal management socket:

   ```
   telnet /var/run/xmlproxyd_mgmt
   Trying /var/run/xmlproxyd_mgmt...
   Connected to /var/run/xmlproxyd_mgmt.
   Escape character is '^]'.
   220 XMLPROXYD release 18.2I20180412_0904_bijchand built by bijchand on 2018-04-12 14:48:48 UTC
   help drend
   ```

   ```
   200-juniper-netconf-get-0 system users <get> RPC
   ```

8. Specify the hierarchy and use the `dr:source` command to map to a container, a list, or a specific leaf. The absolute path under which the sensors will be reported is built from the output group `junos` plus `system-users-information`, concatenated by `/`'. The path `/junos/system-users-information/` is the path to query for information about this custom sensor.

   WARNING: You should not create a custom YANG model that conflicts or overlaps with predefined native paths (Juniper defined paths) and OpenConfig paths (resources). Doing so can result in undefined behavior.

   For example, do not create a model that defines new leafs at or augments nodes for resource paths such as `/junos/system/linecard/firewall`or `/interfaces`.

   A one-to-one mapping between container, leafs and the XML tag or value from the CLI command output is defined in the grouping referenced by `uses` within the output container. A *grouping* can be referred to multiple times in different container outputs. The container `system-users-information` below uses the grouping system-users-information. However, it is defined without the aforementioned one-to-one mapping for every container, list and leaf to an output XML tag from the CLI command XML output.

```
output {
    container junos {
        container system-users-information {
            dr:source "/system-users-information“;
            uses system-users-information-grouping;
        }
    }
}
```

9. The following YANG file shows how to include these commands to enable the `xmlproxyd` process to retrieve the full operational state and map it to the leafs in Juniper's own data model:

```
*/



/*
 * Example yang for generating OpenConfig equivalent of show system users
 */

module xmlproxyd_sysusers {
  yang-version 1;
```

```
namespace "http://juniper.net/yang/software";

import drend {
  prefix dr;
}

grouping system-users-information-grouping {
  container uptime-information {
    dr:source "uptime-information";
    leaf date-time {
      type string;
      dr:source date-time;
    }
    leaf up-time {
      type string;
      dr:source up-time;
    }
    leaf active-user-count {
      type int32;
      dr:source active-user-count;
    }
    leaf load-average-1 {
      type string;
      dr:source load-average-1;
    }
    leaf load-average-5 {
      type string;
      dr:source load-average-5;
    }
    leaf load-average-15 {
      type string;
      dr:source load-average-15;
    }
    container user-table {
      dr:source "user-table";
      list user-entry {
        key "user";
        dr:source "user-entry";
        leaf user {
          dr:source user;
          type string;
        }
        leaf tty {
```

```
          dr:source tty;
          type string;
        }
        leaf from {
          dr:source from;
          type string;
        }
        leaf login-time {
          dr:source login-time;
          type string;
        }
        leaf idle-time {
          dr:source idle-time;
          type string;
        }
        leaf command {
          dr:source command;
          type string;
        }
      }
    }
  }
}

dr:command-app "xmlproxyd";
rpc juniper-netconf-get {
  dr:command-top-of-output "/company-name";
  dr:command-full-name "drend juniper-netconf-get";
  dr:cli-command "show system users";
  dr:command-help "default <get> rpc”;
output {
    container company-name {
      container system-users-information {
        dr:source "/system-users-information";
        uses system-users-information-grouping;
      }
    }
  }
}
}
```

Load the Yang File in Junos

After the YANG file is complete, upload the YANG file and verify that the module is created.

1. Upload the YANG file to the router.
2. Register the YANG file using the `request system yang add package` command.

```
user@switch> request system yang add package sysusers proxy-xml module xmlproxyd_sysusers.yang
XML proxy YANG module validation for xmlproxyd_sysusers.yang : START
XML proxy YANG module validation for xmlproxyd_sysusers.yang : SUCCESS
JSON generation for xmlproxyd_sysusers.yang : START
JSON generation for xmlproxyd_sysusers.yang: SUCCESS
```

NOTE: Starting in Junos OS Release 18.3R1, adding, deleting, or updating YANG packages in configuration mode with the `run` command is not supported.

3. Verify that the module (sensor) is registered using the `show system yang package sysusers` command, where `sysusers` is the name of the package:

```
user@switch> show system yang package sysusers
Package ID               :sysusers
XML Proxy YANG Module(s) :xmlproxyd_sysusers.yang
```

4. Enable gRPC in the Junos OS configuration:

```
user@switch> set system services extension-service request-response grpc port 32767
```

Collect Sensor Data

IN THIS SECTION

Use your favorite collector to pull the newly created telemetry sensor data from the device.

Consider resource constraints before initiating sensors:

- Avoid specifying the same reporting interval for multiple XML proxy sensors.
- Because xmlproxyd performs XML and text processing, a device should only contain XML proxy sensors that execute within the CPU utilization range.

Platform-Specific Collecting Sensor Data Behavior

Use Feature Explorer to confirm platform and release support for specific features.

Use the following table to review platform-specific behaviors for your platforms:

Table 9: Collecting Sensor Data Behavior

Platform	Difference
PTX10008	For PTX10008 routers operating Junos OS Evolved, do not connect more than 10 collectors per router for telemetry RPCs.

The following instructions use the collector *jtimon*. For information about jtimon setup, see Junos Telemetry Interface client.

NOTE: If a subscription already exists for a sensor and a duplicate subscription is configured, the connection between the collector and the device will close with the error message `AlreadyExists`.

1. Create a simple configuration file, here named `vmx1.json`. Adjust the host IP address and the port, as needed. The path `/junos/system-users-information` is specified. The `freq` field is defined in MicroSoft, streaming a new set of key value pairs every 5 seconds. Optionally, you can add multiple paths.

```
$ cat vmx1.json
{
  "host": "172.16.122.182
  "port": 32767
  "cid": "my-client-id",
  "grpc" : {
    "ws" : 524289
  },
```

```
  "paths": {
    {
      "path": "/junos/system-users-information/",
      "freq": 5000
    },
    {
      "path": "/junos/additional-path/",  <-OPTIONAL
      "freq": 5000
    }
   }
}
```

2. Launch the collector, using either your own compiled file or an automatically built image from Docker Hub. The sample query output below shows the sensor report by path. Every key is sent in human-readable form as an absolute path. In case of lists, the absolute path contains an index in the form of XPATH which is ideal to group values from a (time series) database, such as InfluxDB. For example, the output below shows the path `/junos/system-users-information/uptime-information/user-table/user-entry[user='ab']/`.

   You can terminate the stream of sensor data using Ctrl-C.

```
$ docker run -tu --rm -v $(PWD):/u mw/jtimon --config vmx1.json --print
gRPC headers from Junos:
  init-response: [response { subscription_id 1} path_list {path: "junos/system-users-information/" sample-frequency: 5000 } ]
  content-type: [application/grpc]
  grpc-accept-encoding: [identity,deflate,gzip]
2018/03/04 17:13:19 system-id vmxdockerlight_vmx1_1
2018/03/04 17:13:19 component_id 65535
2018/03/04 17:13:19 sub_component_id: 0
2018/03/04 17:13:19 path: sensor_1000:/junos/system-users-information/:/junos/system-users-information/
2018/03/04 17:13:19 sequence_number: 16689
2018/03/04 17:13:19 timestamp: 1520183589391
2018/03/04 17:13:19 sync_response: %!d(bool=false)
2018/03/04 17:13:19 key: __timestamp__
2018/03/04 17:13:19 uint_value: 1520183589391
2018/03/04 17:13:19 key: __junos_re_stream_creation_timestamp--
2018/03/04 17:13:19 uint value: 1520183589372
2018/03/04 17:13:19 key: __junos_re_payload-get_timestamp__
2018/03/04 17:13:19 uint_value: 1520183589390
2018/03/04 17:13:19 key: /junos/system-users-information/uptime-information/date-time
2018/03/04 17:13:19 str-value: 5:13PM
```

```
2018/03/04 17:13:19 key: /junos/system-users-inforamtion/uptime-information/up-time
2018/03/04 17:13:19 str-value: 1 day, 4:10
2018/03/04 17:13:19 key: /junos/system-users-information/uptime-information/active-user-count
2018/03/04 17:13:19 int_value: 2
2018/03/04 17:13:19 key: /junos/system-users-inforamtion/uptime-information/load-average-1
2018/03/04 17:13:19 str_value: 0.62
2018/03/04 17:13:19 key: /junos/system-users-information/uptime-information/load-average-5
2018/03/04 17:13:19 str_value: 0.56
2018/03/04 17:13:19 key: /junos/system-users-inforamtion/uptime-information/load-average-15
2018/03/04 17:13:19 str_value: 0.53
2018/03/04 17:13:19 key: __prefix__
2018/03/04 17:13:19 str_value: /junos/system-users-information/uptime-information/user-table/
user-entry[user='ab']/
2018/03/04 17:13:19 key: tty
2018/03/04 17:13:19 str_value: pts/1
2018/03/04 17:13:19 key: from
2018/03/04 17:13:19 str-value: 172,16.04.25
2018/03/04 17:13:19 key: login-time
2018/03/04 17:13:19 str_value: 5:12PM
2018/03/04 17:13:19 key: idle-time
2018/03/04 17:13:19 str-value: -
2018/03/04 17:13:19 key: command
2018/03/04 17:13:19 str_value: -cl
2018/03/04 17:13:19 system_id: vmxdockerlight_vmx1_1
2018/03/04 17:13:19 component_id: 65535
2018/03/04 17:13:19 sub_component_id: 0
2018/03/04 17:13:19 <output truncated>
```

The sample query shown below shows two sensor reports per path, then I terminated it with Ctrl-C. Every key is sent in human readable form as an absolute path and in case of lists, contains an index in form of XPATH, ideal to group values from a (time series) database like InfluxDB e.g. /junos/system-users-information/uptime-information/user-table/user-entry[user='ab']/

3. Verify that the module (sensor) is loaded using the `show system yang package sysusers` command, where `sysusers` is the name of the package:

```
user@switch> show system yang package sysusers
Package ID               :sysusers
XML Proxy YANG Module(s) :xmlproxyd_sysusers.yang
```

4. Enable gRPC in the Junos OS configuration:

```
user@switch> set system services extension-service request-response grpc port 32767
```

Installing a User-Defined YANG File

To add, validate, modify, or delete a user-defined YANG file for XML proxy for the Junos telemetry interface, use the `request system yang` set of commands from the operational mode:

1. Specify the name of the XML proxy YANG file and the file path to install it. This command creates a `.json` file in the `/opt/lib/render` directory.

```
user@switch> request system yang add package package-name proxy-xml module file-path-name
```

NOTE: This command can be performed only on the current routing engine.

To add multiple YANG modules with the `request system yang add package` *`package-name`* `proxy-xml module` command, enclose the *`file-path-name`* in brackets: `[` *`file-path-name 1 file-path-name 2`* `]`

2. (Optional) Validate an module before adding it to the router using the **request system yang validate proxy-xml module *module-name*** command. .

```
user@switch> request system yang validate proxy-xml module module-name
```

The output `XML proxy YANG module validation for xmlproxyd_<module-name> : SUCCESS` indicates successful module validation.

Mismatch error sometimes occur. If the command returns the error below, you can eliminate the error by using Junos OS Release 18.1R1 or later:

```
user@switch> request system yang validate proxy-xml module xmlproxyd_sysusers.yang
error: illegal identifier <identifier> , must not start with [xX][mM][lL]
```

3. (Optional) Update an existing XML proxy YANG file that was previously added.

```
user@switch> request system yang update package-name proxy-xml module file-path-name
```

4. Delete an existing XML proxy YANG file.

```
user@switch> request system yang delete package-name
```

5. Verify that the YANG file has been installed by entering the `show system yang package` command.

```
user@switch> show system yang package package-name
```

Troubleshoot Telemetry Sensors

IN THIS SECTION

Problem

Description

Use the following methods to troubleshoot user-define telemetry sensors:

- Execute a tcpdump for the interface your gRPC requests came from (for this task, interface `fxp0` was used).

```
user@switch>monitor traffic interface fxp0 no-resolve matching "tcp port 32767"
```

- Enable traceoptions using the **set services analytics traceoptions flag xmlproxy** command. Check the `xmlproxyd` log file for confirmation of whether the CLI command's RPC was sent and if a response was received:

1. Issue the **show log xmlproxyd** command to show the xmlproxyd log. The value for the field `xmlproxy_execute_cli_command:` indicates if the RPC was sent or not. The value for the field `xmlproxy_build_context` indicates the command.

```
user@switch>show log xmlproxyd
Mar 4 18:52:46 vmxdockerlight_vmx1_1 clear-log[52495]: logfile cleared
Mar  4 18:52:51 xmlproxy_telemetry_start_streaming: sensor /junos/system-users-information/
Mar  4 18:52:51 xmlproxy_build_context: command show system users merge-tag:
Mar  4 18:52:51 <command format="xml">show system users</command>
Mar  4 18:52:51 xmlproxy_execute_cli_command: Sent RPC..
Mar  4 18:52:51 <system-users-information xmlns="http://xml.juniper.net/junos/17.4R1/junos"
xmlns:junos="http://xml.juniper.net/junos/*/junos">
<uptime-information>
<date-time junos:seconds="1520189571">
6:52PM
</date-time>
<up-time junos:seconds="107400">
1 day,  5:50
</up-time>
<active-user-count junos:format="1 users">
1
</active-user-count>
<load-average-1>
0.94
</load-average-1>
<load-average-5>
0.73
</load-average-5>
<load-average-15>
0.65
```

RELATED DOCUMENTATION

Understanding YANG on Devices Running Junos OS

Guidelines for gRPC and gNMI Sensors (Junos Telemetry Interface)

Send Requests to the NETCONF Server

Streaming Syslog Data to Telemetry Collectors

Starting with Junos OS Release 18.1R1, you can stream syslog event data to your telemetry collectors. This is done by enabling the /junos/events/ sensor and configuring an export profile with a reporting rate of "0" (continuous streaming). The streamed data includes both event details (like device state changes and configuration activities) and standard telemetry metrics.

Support for Zero Suppression

The zero-suppression feature on Juniper devices controls how data is exported from sensors. When zero-suppression is enabled, sensor values of zero aren't sent to the collector. Enabling zero-suppression reduces data transmission and storage by focusing on non-zero values.

However, if zero-suppression is disabled (using the no-zero-suppression configuration), all sensor values, including zeros, are sent to the collector. Disabling zero-suppression ensures users see all counters, including those with a zero value.

Change History Table

Feature support is determined by the platform and release you are using. Use Feature Explorer to determine if a feature is supported on your platform.

Release	Description
25.4R1	When no-zero-suppression is enabled for SR and mLDP sensors, all logical interfaces on the device will stream even zero values the collector.
23.4R1	All zeros are streamed for MPLS LSP statistics even if no-zero-suppression is configured.

Configure SR-TE for Uncolored Ingress LSPs

IN THIS SECTION

Enable SR-TE telemetry statistics by first configuring SR-TE on a device.

Supporting Uncolored Sensor Paths

Segment routing uses a segment list to enable static segment routing LSPs to steer traffic based on segment routing policies. When a protocol uses a segment list, it validates the segment identifiers and selects valid segments for traffic engineering.

Configure the `segment-list` of a segment routing traffic engineering (SR-TE) LSP to accept both IP addresses and labels. Two models are based on these parameters:

1. Direct resolution - The LSP accepts an IP address as the first hop.
2. Indirect resolution - This model uses only labels.

Table 10 on page 151 lists the segment routing traffic engineering (SR-TE) ingress sensors installed on the packet forwarding engine to view the statistics that are enabled in an SR-TE configuration.

Table 10: SR-TE Ingress Sensors

Path	Sensor	Sensor Name	Sensor Subtype	Description
2	**/junos/services/segment-routing/traffic-engineering/tunnel/ingress/usage/**	ingress-lsp1	SRTE TUNNEL INGRESS	Streams uncolored SR-TE tunnel statistics.
3	**/junos/services/segment-routing/traffic-engineering/tunnel/lsp/ingress/usage/**	i;st;0;f;lsp1;path1 i;st;0;f;lsp1;path2	SRTE PER-TUNNEL PER-LSP INGRESS	Streams uncolored SR-TE per-tunnel statistics.

To stream statistics for the sensors, configure SR-TE for each path and enable statistics to collect data streamed through a sensor subscription from a device to a collector. See the sections below for sample configurations and operational mode output.

Configure SR-TE for Uncolored SR-TE Tunnel Statistics

To stream uncolored SR-TE tunnel statistics, refer to the uncolored SR-TE configuration below to create a segment list and enable static segment routing LSPs to steer traffic based on segment routing policies.

Configure Path 2

```
[edit]
set protocols source-packet-routing segment-list path1 hop1 label 50100
set protocols source-packet-routing segment-list path2 hop1 label 50100
set protocols source-packet-routing source-routing-path lsp1 to 100.100.100.100
set protocols source-packet-routing source-routing-path lsp1 primary path1
set protocols source-packet-routing source-routing-path lsp1 primary path2
set protocols source-packet-routing telemetry statistics
```

Use the `show agent sensors detail` operational mode command to display `ingress-lsp1` sensor details.

```
user@host> show agent sensors detail
SID                 Name                  Type         Subtype             Packets
Bytes        Requests         Replies      Count        CounterTokens[updates]
281478734807051     ingress-lsp1          SR           srte-uncolored-ingress 10
920          12               12            1           1615[36],
```

Configure SR-TE for Uncolored SR-TE Per-tunnel Statistics

To stream uncolored SR-TE per-tunnel statistics, refer to the uncolored SR-TE configuration below to create a segment list and enable static segment routing LSPs to steer traffic based on segment routing policies.

Configure Path 3

```
[edit]
set protocols source-packet-routing segment-list path1 hop1 label 50100
set protocols source-packet-routing segment-list path2 hop1 label 50100
set protocols source-packet-routing source-routing-path lsp1 to 100.100.100.100
set protocols source-packet-routing source-routing-path lsp1 primary path1
set protocols source-packet-routing source-routing-path lsp1 primary path2
set protocols source-packet-routing telemetry statistics per-source per-segment-list
```

Use the `show agent sensors detail` operational mode command to display sensor `i;st;0;f;lsp1;path1` and sensor `i;st;0;f;lsp1;path2` details.

```
user@host> show agent sensors detail
SID                 Name                  Type         Subtype            Packets
Bytes        Requests         Replies      Count        CounterTokens[updates]
281478734807049    i;st;0;f;lsp1;path1    SR           srte-per-lsp-ingress 6
552          24               24            1           1611[18514],
281478734807050    i;st;0;f;lsp1;path2    SR           srte-per-lsp-ingress 0
0            24               0             1            1           1615[36],
```

SEE ALSO

routing-instance (Junos Telemetry Interface)

Per-Path or Per-Segment-List Traffic Statistics

IN THIS SECTION

The Segment Routing Traffic Engineering (SRTE) Traffic Statistics Collection feature enables you to gather traffic statistics for both ingress IP traffic and transit MPLS traffic traversing SRTE tunnels. This functionality allows you to configure statistics at both the tunnel level and the per-path level, providing granular insights into traffic flow. This section describes about the applied per-path or per-segment-list traffic statistics that is unique for each sub candidate path of a SRTE tunnel.

You can configure per-segment-list to enable SRTE to generate a sensor ID and statistics handler. SRTE route gateways download the statistics handler, including the sensor ID. The handler operates the gateway during route programming, pushing sensor information to the Packet Forwarding Engine (PFE) if the system downloads the route to the Forwarding Information Base (FIB). To collect traffic statistics from the PFE, two optional path-level sensors are available: Ingress and Transit.

Sensor name generation varies for colored and uncolored tunnels.

- For colored tunnels, the sensor name format remains unchanged. The segment ID, previously filled with the sub-candidate path ID, now uses the segment-list ID.
- For uncolored tunnels, reuse the last component of the sensor name (lsp-name) to fill the segment-list ID instead of the sub-candidate path name. The segment ID uses a hexadecimal format for both tunnel types.

A sample shows the sensor name format and highlights changes in that format.

Table 11: Sensor Name Format

Tunnel Type	Sensor Type	Current Format	Format after the change
Colored	Ingress	4.4.4.4-2-1e-0-0.0.0.0-0-80	4.4.4.4-2-1e-0-0.0.0.0-0-80
	Transit	4.4.4.4-2-1e-0-0.0.0.0-0-80-f4241	4.4.4.4-2-1e-0-0.0.0.0-0-80-f4241
Uncolored	Ingress	i;st;0;f;tunnel-1;**SCpath1**	i;st;0;f;tunnel-1;**80**
	Transit	t;st;0;f;tunnel-1;**SCpath1**	t;st;0;f;tunnel-1;**80**

Configuring Per-Path Traffic Statistics

IN THIS SECTION

Configuration

By configuring per-segment-list sensor, a unique telemetry sensor is created for each segment-list.

```
user@host# show protocols source-packet-routing telemetry
statistics {
    per-source {
        per-segment-list;
    }
}
user@host# show protocols source-packet-routing segment-list SCpath2
hop1 label 400300;
hop2 label 400400;

{master}[edit]
user@host# show protocols source-packet-routing segment-list SCpath1
hop1 label 400400;
user@host# show protocols source-packet-routing source-routing-path tunnel-1
to 4.4.4.4;
binding-sid 1000010;
primary {
    SCpath1;
    SCpath2;
}
user@host# show spring-traffic-engineering lsp name tunnel-1 detail
```

The output of the above configuration is as shown here:

```
Name: tunnel-1
  Tunnel-source: Static configuration
  Tunnel Forward Type: SRMPLS
  To: 4.4.4.4-10<c>
  Binding SID Label:1000010
    20 Bit MPLS Label, State: Allocated
  State: Up
    Path: SCpath1
    Path Status: Up
    Outgoing interface: NA
    Auto-translate status: Disabled Auto-translate result: N/A
    Compute Status:Enabled , Compute Result:success , Compute-Profile Name:pro1
    Total number of computed paths: 2
```

```
      Segment ID : 128
      Telemetry Ingress statistics:
      Sensor-name: 4.4.4.4-a-1e-0-0.0.0.0-0-80, Id: 3758096417
      Telemetry transit statistics:
      Sensor-name: 4.4.4.4-a-1e-0-0.0.0.0-0-80-f424a, Id: 3758096418
      Computed-path-index: 1
        BFD status: N/A BFD name: N/A
        BFD remote-discriminator: N/A
        TE metric: 30, IGP metric: 30
        Delay metrics: Min: 50331645, Max: 50331645, Avg: 50331645
        Metric optimized by type: TE
        computed segments count: 3
          computed segment : 1 (computed-adjacency-segment):
            label: 400103
            source router-id: 1.1.1.1, destination router-id: 2.2.2.2
            source interface-address: 11.2.1.1, destination interface-address: 11.2.1.2
          computed segment : 2 (computed-adjacency-segment):
            label: 400202
            source router-id: 2.2.2.2, destination router-id: 3.3.3.3
            source interface-address: 22.1.1.2, destination interface-address: 22.1.1.3
          computed segment : 3 (computed-adjacency-segment):
            label: 400301
            source router-id: 3.3.3.3, destination router-id: 4.4.4.4
            source interface-address: 33.1.1.3, destination interface-address: 33.1.1.4
      Segment ID : 129
      Telemetry Ingress statistics:
      Sensor-name: 4.4.4.4-a-1e-0-0.0.0.0-0-81, Id: 3758096419
      Telemetry transit statistics:
      Sensor-name: 4.4.4.4-a-1e-0-0.0.0.0-0-81-f424a, Id: 3758096420
      Computed-path-index: 2
        BFD status: N/A BFD name: N/A
        BFD remote-discriminator: N/A
        TE metric: 30, IGP metric: 30
        Delay metrics: Min: 50331645, Max: 50331645, Avg: 50331645
        Metric optimized by type: TE
        computed segments count: 3
          computed segment : 1 (computed-adjacency-segment):
            label: 400105
            source router-id: 1.1.1.1, destination router-id: 2.2.2.2
            source interface-address: 11.4.1.1, destination interface-address: 11.4.1.2
          computed segment : 2 (computed-adjacency-segment):
            label: 400202
            source router-id: 2.2.2.2, destination router-id: 3.3.3.3
```

```
          source interface-address: 22.1.1.2, destination interface-address: 22.1.1.3
        computed segment : 3 (computed-adjacency-segment):
          label: 400301
          source router-id: 3.3.3.3, destination router-id: 4.4.4.4
          source interface-address: 33.1.1.3, destination interface-address: 33.1.1.4
    Path: SCpath2
    Path Status: Up
    Outgoing interface: NA
    Auto-translate status: Disabled Auto-translate result: N/A
    Compute Status:Enabled , Compute Result:success , Compute-Profile Name:pro2
    Total number of computed paths: 2
    Segment ID : 256
    Telemetry Ingress statistics:
    Sensor-name: 4.4.4.4-a-1e-0-0.0.0.0-0-100, Id: 3758096421
Telemetry transit statistics:
    Sensor-name: 4.4.4.4-a-1e-0-0.0.0.0-0-100-f424a, Id: 3758096422
    Computed-path-index: 1
      BFD status: N/A BFD name: N/A
      BFD remote-discriminator: N/A
      TE metric: 30, IGP metric: 30
      Delay metrics: Min: 50331645, Max: 50331645, Avg: 50331645
      Metric optimized by type: Minimum-Delay
      computed segments count: 3
        computed segment : 1 (computed-adjacency-segment):
          label: 400103
          source router-id: 1.1.1.1, destination router-id: 2.2.2.2
          source interface-address: 11.2.1.1, destination interface-address: 11.2.1.2
        computed segment : 2 (computed-adjacency-segment):
          label: 400202
          source router-id: 2.2.2.2, destination router-id: 3.3.3.3
          source interface-address: 22.1.1.2, destination interface-address: 22.1.1.3
        computed segment : 3 (computed-adjacency-segment):
          label: 400301
          source router-id: 3.3.3.3, destination router-id: 4.4.4.4
          source interface-address: 33.1.1.3, destination interface-address: 33.1.1.4
    Segment ID : 257
    Telemetry Ingress statistics:
    Sensor-name: 4.4.4.4-a-1e-0-0.0.0.0-0-101, Id: 3758096423
    Telemetry transit statistics:
    Sensor-name: 4.4.4.4-a-1e-0-0.0.0.0-0-101-f424a, Id: 3758096424
    Computed-path-index: 2
      BFD status: N/A BFD name: N/A
      BFD remote-discriminator: N/A
```

```
        TE metric: 30, IGP metric: 30
        Delay metrics: Min: 50331645, Max: 50331645, Avg: 50331645
        Metric optimized by type: Minimum-Delay
        computed segments count: 3
          computed segment : 1 (computed-adjacency-segment):
            label: 400105
            source router-id: 1.1.1.1, destination router-id: 2.2.2.2
            source interface-address: 11.4.1.1, destination interface-address: 11.4.1.2
          computed segment : 2 (computed-adjacency-segment):
            label: 400202
            source router-id: 2.2.2.2, destination router-id: 3.3.3.3
            source interface-address: 22.1.1.2, destination interface-address: 22.1.1.3
          computed segment : 3 (computed-adjacency-segment):
            label: 400301
            source router-id: 3.3.3.3, destination router-id: 4.4.4.4
            source interface-address: 33.1.1.3, destination interface-address: 33.1.1.4
```

SRv6 and SRv6-TE Traffic Sensor Telemetry

SUMMARY

Segment Routing over IPv6 (SRv6) telemetry support provides a powerful mechanism for monitoring and optimizing network performance. By leveraging the native SRv6 data model, you can integrate telemetry tools that provide comprehensive insights into network traffic. These insights are gathered using streaming XPath from the SRv6 Manager and rpd, which collect and transmit detailed traffic statistics. SRv6 telemetry helps maintain stable network performance and security. It enables monitoring of real-time traffic patterns, detection of anomalies, and prompt responses to potential issues.

IN THIS SECTION

The telemetry support for SRv6 provides a unified data model for both SRv6 and SRv6 TE tunnels. This standardization enables consistent management and monitoring of different tunneling technologies within users' networks. Although the current implementation focuses on SRv6 TE tunnels, the foundation is present for broader support in future updates. The data model ensures consistency, enabling telemetry configuration and management across various network segments.

To enable effective traffic monitoring, traffic sensors are installed on routes and next hops within the rpd. These sensors are mapped to ISIS and SRTE sensors, allowing the Packet Forwarding Engine (PFE) to collect and stream traffic statistics. This integration provides detailed visibility into network performance, enabling proactive management and troubleshooting. By monitoring traffic at a granular level, you can optimize routing decisions, improve network efficiency, and enhance overall operational reliability.

Following are some of the functionalities of SRv6 in telemetry:

- **Traffic Statistics telemetry for IGP (ISIS Only) Routes / NextHops:** Following is the list of PFE sensors, which are installed by IS-IS based upon the newly introduced configuration commands and streamed by PFE.

Table 12: Traffic Statistics telemetry for IGP Routes or NextHops.

Sensor Path	Description
`/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/srv6/remote-locators/remote-locator[address]/counters/in-pkts/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/srv6/remote-locators/remote-locator[address]/counters/in-octets`	This sensor path is applicable for PFE sensor for Remote SRv6 locator routes in INET6.0 RT.
`/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/srv6/remote-locators/remote-locator[address]/counters/out-pkts/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/srv6/remote-locators/remote-locator[address]/counters/out-octets`	This sensor path is applicable for PFE sensor for Remote SRv6 Locator Route TCNH Gateway in INET6.3 RT.

- **Support for Uniformed Native Data Model for SR-TE:** This feature includes a model tree for both colored and uncolored policies. Only SRv6-TE FIB Xpaths (traffic counter) with ingress counters are supported for both tunnel types. SRv6 TE traffic counter Xpaths streaming is platform-dependent, applicable only to JUNOS MX platforms. At PFE, stats accounting occurs before policy application, supporting only ingress counters. SRv6-TE sensors support only the DEFAULT instance.

- **Colored SRv6-TE per policy ingress counters:** The supported counters are listed here-

Table 13: Colored SRv6-TE per-policy Ingress Counters

Sensor Path	Description
`/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/te-policies/te-policy[color endpoint]/counters/srv6/in-bytes`	This sensor path is applicable for per-policy level PFE sensors pfor SRv6 SR-TE route TCNH gateway in junos-rti table.
`/state routing-instances/routing-instance[name]/protocols/source-packet-routing/te-policies/te-policy[color endpoint]/counters/srv6/in-pkts`	This sensor path is applicable for ingress SRv6 traffic.

NOTE: When per-policy counters are streamed, the values are cumulative of all the candidate-paths of that policy.

- **Colored SRv6-TE per path ingress counters:** The supported counters are listed here-

Table 14: Colored SRv6-TE per-path Ingress Counters

Sensor Path	Description
`/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/te-policies/te-policy[color endpoint]/candidate-paths/candidate-path[protocol-origin originator-asn originator-address discriminator]/segment-lists/segment-list[segment-id]/counters/in-bytes`	This sensor path is applicable for per-path level PFE sensors for SRv6 SR-TE route TCNH gateway in junos-rti table.
`/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/te-policies/te-policy[color endpoint]/candidate-paths/candidate-path[protocol-origin originator-asn originator-address discriminator]/segment-lists/segment-list[segment-id]/counters/in pkts`	This sensor path is applicable for ingress SRv6 traffic.

- **Uncolored SRv6-TE per tunnel ingress counters:** The supported counters are listed here-

Table 15: Uncolored SRv6-TE per-tunnel Ingress Counters

Sensor Path	Description
`/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/uncolored-te-tunnels/uncolored-te-tunnel[name]/counters/in-bytes`	This sensor path is applicable for per-policy level PFE sensors for SRv6 SRTE uncolored route TCNH gateway in inet6.3 table.
`/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/uncolored-te-tunnels/uncolored-te-tunnel[name]/counters/in-pkts`	This sensor path is applicable for ingress SRv6 traffic.

- **Uncolored SRv6-TE per path ingress counters:** The supported counters are listed here-

Table 16: Uncolored SRv6-TE per-path Ingress Counters

Sensor Path	Description
/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/uncolored-te-tunnels/uncolored-te-tunnel[name]/segment-lists/segment-list[segment-id]/counters/in-bytes	This sensor path is applicable for per-path level PFE sensors for SRv6 SRTE uncolored route TCNH gateway in inet6.3 table.
/state/routing-instances/routing-instance[name]/protocols/source-packet-routing/uncolored-te-tunnels/uncolored-te-tunnel[name]/segment-lists/segment-list[segment-id]/counters/in-pkts	This sensor path is applicable for ingress SRv6 traffic.

Benefits of SRv6 and SRv6-TE Traffic Sensor Telemetry

- Enhances network performance monitoring through detailed traffic statistics, allowing you to track packet and byte counts for both ingress and egress traffic.
- Provides granular insights into SRv6 traffic via traffic sensors for IS-IS SRv6 routes and next-hops, facilitating effective network analysis and optimization.
- Supports targeted troubleshooting and optimization by offering ingress counters for both colored and uncolored SRv6-TE policies and paths, enabling precise traffic performance analysis.

- Improves operational efficiency and decision-making through the integrating native YANG data models for SRv6 Base and SRv6-TE, allowing for seamless telemetry data streaming and interpretation.

Limitations

- SR-TE recommends using unique tunnel names for different sources such as Static, PCEP, or BGP-SRTE. Sharing names will result in shared stats.
- Sensor values do not retain during the NSR/GR phase. They change after NSR/GR.

On-Box Aggregation Overview

IN THIS SECTION

Juniper devices support on-box aggregation. Interface, CoS, MPLS, AF, and AE counters are aggregated by the device, and the device then streams telemetry data to a collector. Compared to off-box aggregation, where counters are streamed to the collector and aggregated there, on-box aggregation provides more accurate telemetry data. On-box aggregation also recognizes systemic events, such as line card resets or LAG membership changes. On-box aggregation reduces production errors at the collector. It also significantly reduces the overall telemetry data bandwidth utilization in certain cloud-based environments where data is metered.

Aggregation Logic

Data aggregation is the simple addition of given counter values from all the Packet Forwarding Engine instances received as Google protobuf messages in the aggregation module processes. The aggregation module processes cache the statistics from multiple Packet Forwarding Engines based on the subscription request received. Caching is done per subscription received.

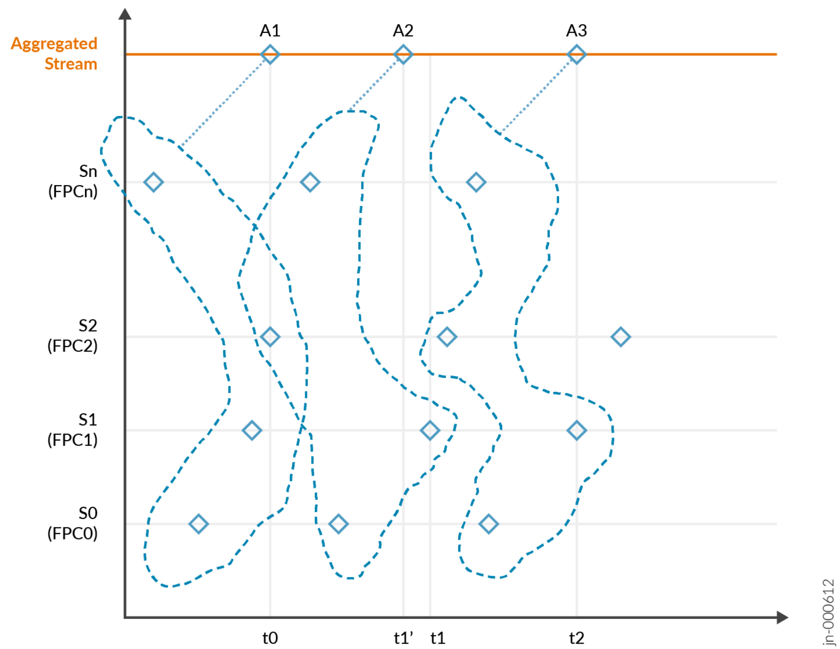
The following points apply to data aggregation:

- If statistical data is gauge type, field values will be either `Average`, `Max` or `Min`, and the aggregation module orders aggregation based on the gauge type field value.
- Aggregation is done for both counter and gauge data types annotated in the YANG file.
- At any time, there is only one source of data for a given Packet Forwarding Engine available in the cache. New entries overwrite the existing cache.
- No separate timer aggregates or streams data. Whenever sample data is received from a Packet Forwarding Engine, the time to aggregate and stream is checked with the previously sent aggregated timestamp. For example:
- current time stamp – previously aggregated time stamp > reporting_interval
- The export timestamp carries a median timestamp for the aggregated data.
- Record caching in the na-grpcd daemon is available only while the subscription is valid (active). When a subscription is inactive, the exported aggregated telemetry data might not match the Routing Engine command line interface statistics. The following triggers may create this mismatch:
  - Restart of one or more FPCs in which the child members are part of the aggregated interface.
  - Deletion of up to n-1 child members (at least one child link is active) from an aggregate interface.
- Lastly, if the subscription is deleted, the associated cache also is deleted.

In a gNMI or gRPC stream, the first sample may not contain aggregated statistics counter values because the first interval from the Routing Engine may have only received one sample from multiple FPCs. However, from the second interval onwards, the stream will contain aggregated counter values received from all the FPCs.

Aggregation of samples is triggered based upon one of the incoming samples. Shown in Figure 6 on page 164, sample S2 is delayed. Because of this delay, A2 aggregation uses the old t0 sample with a median timestamp of the samples. This is labeled t1' (though actually it is t1).

Figure 6: Aggregation of Sample Intervals



Packet Forwarding Engine Data Export

The aggregation feature relies on the fundamental protobuf-based telemetry interface to export data from the Packet Forwarding Engine. A protobuf-based telemetry stream encapsulates data for export in a common, top-level envelope called **TelemetryStream** (shown below).

```
message TelemetryStream {
    // router hostname
    // (or, just in the case of legacy (microkernel) PFEs, the IP address)
    required string system_id        = 1 [(telemetry_options).is_key = true];

    // line card / RE (slot number)
    optional uint32 component_id     = 2 [(telemetry_options).is_key = true];

    // PFE (if applicable)
    optional uint32 sub_component_id = 3 [(telemetry_options).is_key = true];

    // configured sensor name
```

```
    optional string sensor_name      = 4 [(telemetry_options).is_key = true];

    // sequence number, monotonically increasing for each
    // system_id, component_id, sub_component_id + sensor_name.
    optional uint32 sequence_number  = 5;

    // timestamp (milliseconds since 00:00:00 UTC 1/1/1970)
    optional uint64 timestamp        = 6 [(telemetry_options).is_timestamp = true];
…
}
```

This top-level envelope provides necessary information to build the Packet Forwarding Engine statistics cache in an operation called *combinator*. The combinator performs a logical join on multiple data instances that have a common interface ID and queue ID, and produces system-wide aggregated output queue statistics. Every incoming protobuf is organized into the cache using sensor, component and a Packet Forwarding Engine slot field in the **TelemetryStream** protobuf. The combinator keeps track of instance data per Packet Forwarding Engine by caching the latest protobuf export from the Packet Forwarding Engine for a specific sensor. Using binary protobuf as an aggregation unit ensures minimal caching and bookkeeping overhead for each collection of counters contained within the protobuf.

A timestamp on the telemetry data exported from the Packet Forward Engine triggers the aggregate data computation. If the elapsed time since the previous aggregate data export exceeds the sensor refresh interval, then a new aggregate value is exported. This new value uses the timestamp from the last Packet Forwarding Engine sample that triggered the aggregated value export. This method eliminates the need to run a per-sensor timer inside the combinator to reap aggregated data. Also, caching the last received data export from the Packet Forwarding Engine minimizes "drift" in the exported aggregate data. This is especially useful for instances such as a delayed Packet Forwarding Engine export as well as operational changes that can potentially preclude further export from the Packet Forwarding Engine.

Identifying Aggregated Data Samples

You can identify aggregated samples by the header field compoent with the value `na-grpcd`. The na-grpcd daemon produces the aggregated data.

```
system_id: r1q13dep
component_id: 65535
sensor_name: sensor_1004_1_1
subscribed_path: /interfaces/interface/subinterfaces/subinterface/
streamed_path: /interfaces/interface/subinterfaces/subinterface/
```

```
component: na-grpcd
sequence_number: 2097152
export_timestamp: 1663783826926
update {
    timestamp: 1663783826901000000
    prefix: /interfaces/interface[name='ge-1/0/0']/subinterfaces/subinterface[index='16386']
update {
    path {
       elem {
          name:   init-time
       }
    }
    val {
      uint_val: 1663780730
       }
    }
```

Usage Tips

Keep the following considerations in mind when using on-box aggregation:

- The packet and byte rates calculation is based on the aggregated statistics timestamp message. Since the timestamp message is synthesized on one Routing Engine, but is based on cached data from multiple FPCs, the packet and byte rate may not be accurate. Accuracy is higher when the reporting interval configuration is reasonable (as per best practices guidelines).
- If statistics messages are not exported by the Packet Forwarding Engines (for example, the operational status is down), then aggregation statistics are not exported to the collector.
- Expect telemetry MPLS LSP statistics with an AE bundle to have a 5% deviation in packet and byte rates.

Supported Resource Paths

On-box aggregations supports these resource paths:

- **/junos/system/linecard/interface/traffic/**
- **/junos/system/linecard/interface/queue/**

- **/junos/system/linecard/interface/logical/usage/**
- **/junos/system/linecard/cos/interface/interface-set/output/queue/**
- **/junos/services/label-switched-path/usage/**
- **/qos/interfaces/interface/output/queues/queue/state/**
- **/interfaces/interface/state/counters/**
- **/interfaces/interface/subinterfaces/subinterface/state/counters/**
- **/interfaces/interface/subinterfaces/subinterface/ipv4/state/counters/**
- **/interfaces/interface/subinterfaces/subinterface/ipv6/state/counters/**
- **/network-instances/network-instance/mpls/lsps/constrained-path/tunnels/tunnel/state/counters/**
- **/junos/system/linecard/interface/queue/** (CoS native resource path)
- **/junos/system/linecard/qmon-sw/** (CoS native resource path)
- **/qos/interfaces/interface/output/queues/queue/state/** (CoS OpenConfig resource path)
- **/qos/interfaces/interface/input/virtual-output-queues/voq-interface/queues/queue/state/** (CoS OpenConfig resource path)
- **/junos/system/linecard/interface/queue/** (native path for physical interface statistics, AE interfaces supported)
- **/qos/interfaces/interface/output/queues/queue/state/** (AE interfaces supported)

See Junos YANG Data Model Explorer for more information about resource paths, their supported leaves, and the device platforms that support them.

Change History Table

Feature support is determined by the platform and release you are using. Use Feature Explorer to determine if a feature is supported on your platform.

Release	Description
23.2R1	Starting in Junos OS Release 23.2R1, on-box aggregation is supported on interface, CoS, MPLS, and aggregated Ethernet counters. Supported platforms include MX150, MX204, MX240, MX304, MX480, MX960, MX2008, MX2010, MX2020, MX10003, MX10004, MX10008, MX10016, and vMX.

Enabling Export of Subscriber Statistics and Queue Statistics for Dynamic Interfaces and Interface-Sets

IN THIS SECTION

Enabling Export of Subscriber and Queue Statistics for Dynamic Interfaces and Interface-Sets

IN THIS SECTION

You can use subscriber statistics and queue statistics for dynamic interfaces and interface-sets to support remote analytics and monitor Juniper devices that operate as a Broadband Network Gateway (BNG). Using these statistics, you can model and condition traffic flows in a subscriber access network.

About Subscriber and Queue Statistics

Subscriber statistics include the per-IP protocol family (IPv4 or IPv6) packet information (receive and transmitted packets and bytes) for a subscriber interface. Subscriber statistics only include subscriber data forwarded by the system. Filtered and dropped packets and control traffic are factored out and not delivered.

ON-CHANGE subscription support for interface meta-data sends asynchronous notifications when interfaces are created and deleted. After an initial baseline of delivering `create` notifications for all existing interfaces, only notifications for interfaces that are being created or deleted are sent to an external collector.

Use queue statistics to determine oversubscription levels, the mix of forwarding-class traffic, or traffic rates for a given CoS-enabled interface or interface-set.

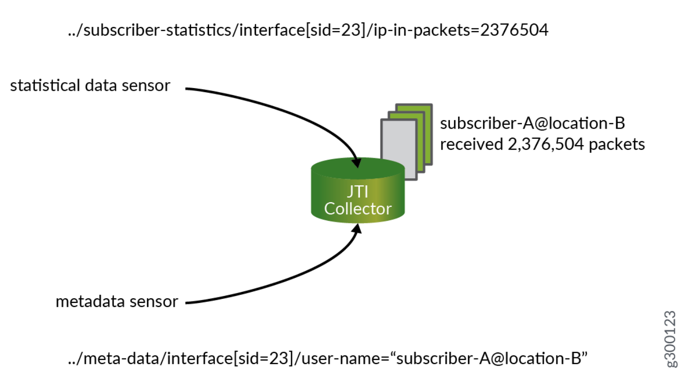
To receive subscriber statistics, you also must enable RADIUS accounting. See *802.1X and RADIUS Accounting*.

Enabling Export of Statistics

To receive statistics, enable both metadata and statistical data for export on your Juniper device through the Junos CLI. Metadata is provided for the interface because the interface key is a dynamic integer, called a session identifier (SID). That identifier conveys no context to an external server. The metadata provides more tangible context (such as a user name, a profile name VLAN tags, and so on) to the SID. An external collector associates the statistical data to a persistent reference.

A subscription for both statistical data and metadata can be made from the external collector (in Figure 7 on page 169, the Junos Telemetry collector). The external collector merges the two streams and correlates the statistical data with the metadata. The external collector matches the dynamic SID with permanent attributes such as username and location.

Figure 7: Junos Telemetry Collector “Merging” Sensor Data



SEE ALSO

gRPC Sensors for Subscriber and Queue Statistics for Dynamic Interfaces and Interface-Sets (Junos Telemetry) | 173

Guidelines for Exporting Subscriber Statistics and Queue Statistics for Dynamic Interfaces and Interface-Sets | 249

telemetry

Enable Export of Subscriber Statistics and Queue Statistics

You can enable the telemetry export of subscriber statistics and queue statistics for dynamic interfaces and interface-sets. After you enable telemetry for these statistics, they are eligible for export to one or more collectors using a remote procedure call (gRPC) subscription.

Use these statistics to model and condition traffic flows in a subscriber access network and to provide subscriber statistics information (accurate accounting).

To enable the export of subscriber statistics and associated interface meta-data:

1. Enable export of interface meta-data and subscriber statistics:

```
[edit dynamic-profiles profile-name]
user@host# set telemetry subscriber-statistics
```

2. Enable the logical demultiplexing (demux) interface in a dynamic profile to export subscriber accurate statistics:

```
[edit dynamic-profiles interfaces demux0]
user@host# unit $junos-interface-unit actual-transit-statistics
```

To enable export of interface meta-data and queue statistics for dynamic interfaces:

1. Enable export of interface meta-data and interface queue statistics. Use the profile variable `$junos-interface-name`.

> **NOTE**: the profile variables `$junos-interface-name` and `$junos-interface-set-name` are generated from the corresponding device, unit and interface-set elements in the interfaces stanza at profile instantiation time. Using these derived variables is a

convenient way to configure telemetry behavior for the interface or interface-set without the need to mimic the specific configuration in the interfaces stanza.

```
[edit dynamic-profiles profile-name]
user@host# set telemetry queue-statistics interface $junos-interface-name
```

2. To override the default internal queue-stats collection interval of 900 seconds or the default queue export filter (all queues, 0-7), add the `rate` and `queues` statements.

```
[edit dynamic-profiles profile-name telemetry queue-statistics interface $junos-interface-name]
user@host# set rate 300
user@host# set queues “0,1,2”
```

To enable export of interface-set meta-data and queue statistics for dynamic interface-sets:

1. Enable export of interface-set meta-data and interface-set queue statistics. Use the profile variable `$junos-interface-set-name`.

NOTE: the profile variables `$junos-interface-name` and `$junos-interface-set-name` are generated from the corresponding device, unit and interface-set elements in the interfaces stanza at profile instantiation time. Using these derived variables is a convenient way to configure telemetry behavior for the interface or interface-set without the need to mimic the specific configuration in the interfaces stanza.

```
[edit dynamic-profiles profile-name]
user@host# set telemetry queue-statistics interface-set $junos-interface-set-name
```

2. To override the default internal queue-stats collection interval of 900 seconds or the default queue export filter (all queues, 0-7), add the `rate` and `queues` statements.

```
[edit dynamic-profiles profile-name telemetry queue-statistics interface-set $junos-interface-
set-name]
user@host# set rate 300
user@host# set queues “0,1,2”
```

After telemetry export is enabled, meta-data and statistics can be streamed to external collectors subscribing to the available resource paths.

Use the resource paths from "gRPC Sensors for Subscriber and Queue Statistics for Dynamic Interfaces and Interface-Sets (Junos Telemetry)" on page 173 for your gRPC subscription.

SEE ALSO

Enabling Export of Subscriber Statistics and Queue Statistics for Dynamic Interfaces and Interface-Sets | 168

Guidelines for Exporting Subscriber Statistics and Queue Statistics for Dynamic Interfaces and Interface-Sets | 249

Configure a NETCONF Proxy Telemetry Sensor in Junos | 134

Guidelines for Exporting Subscriber Statistics and Queue Statistics for Dynamic Interfaces and Interface-Sets

Use subscriber and queue statistics for dynamic interfaces and interface-sets to support remote analytics and monitoring. Juniper Networks MX Series Universal Routers (MX Series) function as a Broadband Network Gateway (BNG).

Before enabling export of subscriber statistics and queue statistics for dynamic interfaces and interface-sets, consider the following limitations:

- On MX Series devices supporting the Modular Port Concentrator 2 (MPC2), a slow internal refresh cycle for queue statistics can occur. This refresh cycle can be lengthy at full line-card scale. This cycle can be lengthy at full line card scale. If the subscription frequency is higher than the internal refresh cycle, exported data may appear stale across reporting intervals.

- The unified in-service software upgrade (ISSU) feature lets you upgrade devices between two different Junos OS releases with no control-plane disruption and minimal traffic disruption. Dynamic interfaces and interface-sets created before ISSU and before Junos OS Release 18.4R1 don't support telemetry for subscriber and queue statistics.

- The subscription frequency must exceed the time required to export telemetry. If the volume of data can't be exported before the next reporting interval, the export continues to completion, and the next reporting interval immediately starts. In such scenarios, continuous streaming results—behavior that might not be wanted.

- Multiple sensors from the dynamic-interfaces sub-tree can be subscribed to simultaneously. Because a single Junos component supports streaming of these sub-tree sensors, the time to export the sensor data for each subscription might extend.

- Enable export only for active queues. To enable export only for active queues, include the `queues` statement at the `[[edit dynamic-profiles profile-name telemetryqueue-statistics $junos-interface-name]` or `[[edit dynamic-profiles profile-name telemetry queue-statistics $junos-interface-set-name]` hierarchy level. This approach reduces the volume of data for each reporting interval.

SEE ALSO

Enabling Export of Subscriber Statistics and Queue Statistics for Dynamic Interfaces and Interface-Sets | 168

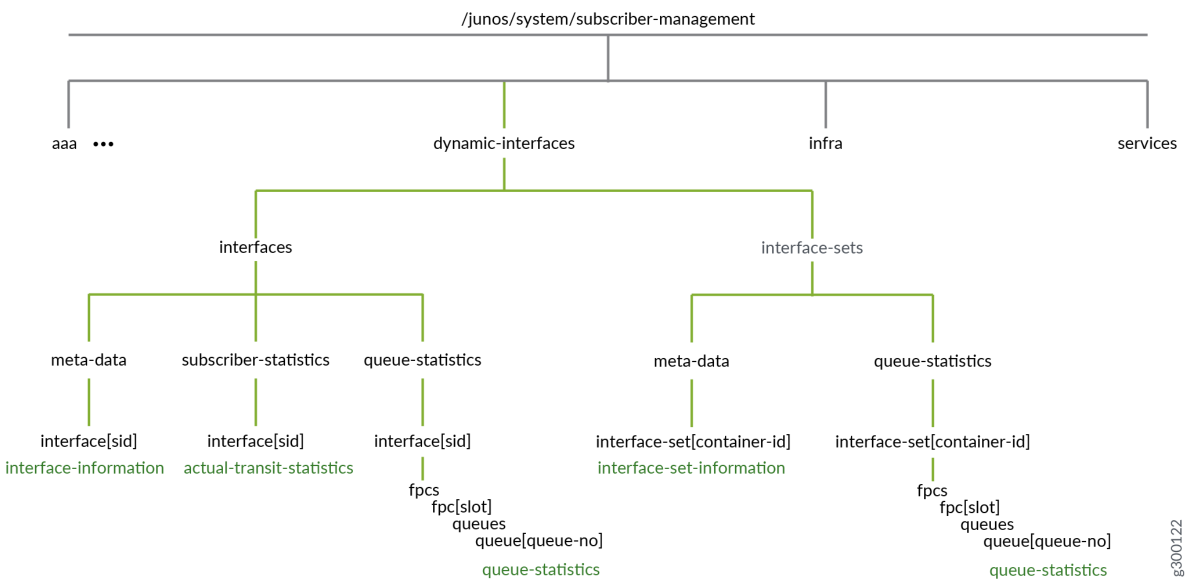
gRPC Sensors for Subscriber and Queue Statistics for Dynamic Interfaces and Interface-Sets (Junos Telemetry)

Starting with Junos OS Release 18.4R1, MX Series routers are supported.

Use subscriber and queue statistics for dynamic interfaces and interface-sets to support remote analytics and monitoring on Juniper devices that operate as a Broadband Network Gateway (BNG). Using these statistics, you can model and condition traffic flows in a subscriber access network.

Figure 8 on page 174 shows the structure of the sensors or resource paths used for subscription to the external collector. The resource paths are a combination of both meta-data and statistical data.

Figure 8: Structure of Sensors



For statistics delivery through a gRPC subscription, include one or more resource paths from Table 17 on page 175 in the subscription. For statistics delivered through gRPC, you will also need to install some additional software enable statistics to be exported on your Juniper device through the Junos CLI. For more information about creating a subscription, see "Configure a NETCONF Proxy Telemetry Sensor in Junos" on page 134 and Enable Export of Subscriber Statistics and Queue Statistics.

Table 17: gRPC Sensors

resource path	Description
`/junos/system/subscriber-management/dynamic-interfaces/interface-sets/meta-data/interface-set[container-id='`*container-id-value*`']/`	Sensor for subscriber interface-set information. This sensor is supported on MX Series routers starting with Junos OS Release 18.4R1. ON-CHANGE streaming is supported. The following end paths are supported: • `cos-egress-tcp-name`-The egress traffic control profile associated with this `interface-set`. • `cos-egress-tcp-remainder-name`-The egress remainder traffic control profile associated with this `interface-set`. • `interface-set-name`-The name of the `interface-set` as supplied by AAA or as constructed by the topology relationship (ACI string or interface stacking). • `interface-set-type`-The type of interface-set (determines structure of interface-set-name). • `device-name`-The name of the underlying device or port (e.g. ge-1/0/0 or ae1). This leaf is empty if the `interface-set-type` is not a physical interface-set type. • `stag`-The outer VLAN tag. The value is 0 if `interface-set-type` is not a VLAN type. • `ctag`-The inner VLAN tag. The value is 0 if `interface-set-type` is not a VLAN type.

Table 17: gRPC Sensors *(Continued)*

resource path	Description
`/junos/system/subscriber-management/dynamic-interfaces/interfaces/meta-data/interface[sid='`*sid-value*`']/`	Sensor for subscriber interface information. ON-CHANGE streaming is supported. The following end paths are supported: • `interface-index`-The system assigned interface index for the interface. • `session-type`-The type of client session (e.g VLAN, DHCP, PPPoE). • `user-name`-The login name for this interface and session. • `profile-name`-The name of the client profile used to create the interface. • `underlying-interface-name`-The name of the associated underlying interface. • `cvlan-tag`-The innermost VLAN tag value associated with the interface. • `svlan-tag`-The outermost VLAN tag value associated with the interface.

Table 17: gRPC Sensors *(Continued)*

resource path	Description
/junos/system/subscriber-management/dynamic-interfaces/interfaces/subscriber-statistics/interface[sid='*sid-value*']/	Sensor for actual accounting statistics for dynamic subscriber interfaces. The following end paths are supported: • ip-in-packets-The number of actual transit IPv4 & IPv6 packets received by the interface. • ip-out-packets-The number of actual transit IPv4 & IPv6 packets sent to the interface. • ip-in-bytes-The number of actual transit IPv4 & IPv6 bytes received by the interface. • ip-out-bytes-The number of actual transit IPv4 & IPv6 bytes received by the interface. • ipv6-in-packets-The number of actual transit IPv6 packets received by the interface. • ipv6-out-packets-The number of actual transit IPv6 packets sent to the interface. • ipv6-in-bytes-The number of actual transit IPv6 bytes received by the interface. • ipv6-out-bytes-The number of actual transit IPv6 bytes sent to the interface.
/junos/system/subscriber-management/dynamic-interfaces/interfaces/queue-statistics/interface[sid='*sid-value*']/fpcs/fpc[slot='*slot-value*']/queues/queue/[queue-no='*queue-no-value*']/	Sensor for queue statistics for dynamic interfaces. The following end paths are supported: • transmitted-packets-The number of actual transit IPv4 & IPv6 packets received by the interface. • transmitted-bytes-Total bytes enqueued for this queue. • dropped-packets-Total packets dropped (because of RED, rate-limited, tail-drop, etc.) for the queue. • dropped-bytes-Total bytes dropped (because of RED, rate-limited, tail-drop, and so on.) for the queue.

Table 17: gRPC Sensors *(Continued)*

resource path	Description
/junos/system/subscriber-management/dynamic-interfaces/interface-sets/queue-statistics/interface-set[container-id='*container-id-value*']/fpcs/fpc[slot='*slot-value*']/queues/queue/[queue-no='*queue-no-value*']/	Sensor for queue statistics for dynamic interface-sets. The following end paths are supported: • `transmitted-packets`-The number of actual transit IPv4 & IPv6 packets received by the interface. • `transmitted-bytes`-Total bytes enqueued for this queue. • `dropped-packets`-Total packets dropped (because of RED, rate-limited, tail-drop, etc.) for the queue. • `dropped-bytes`-Total bytes dropped (because of RED, rate-limited, tail-drop, etc.) for the queue.

SEE ALSO

Explore Sensor Paths | 9

Change History Table

Feature support is determined by the platform and release you are using. Use Feature Explorer to determine if a feature is supported on your platform.

Release	Description
18.4R1	Starting with Junos OS Release 18.4R1, MX Series routers are supported.

Enabling Export of Transit SPRING Statistics

IN THIS SECTION

Export of Transit SPRING Statistics

IN THIS SECTION

Source Packet Routing in Networking (SPRING), also known as segment routing, is a control-plane architecture that enables an ingress router to steer a packet through a specific set of nodes and links in the network. Starting in Junos OS Release 19.1R1, Junos Telemetry supports the export of transit SPRING statistics on PTX3000 routers and PTX5000 routers with FPC2. Use these statistics to monitor traffic, model engineering, and plan capacity.

Transit Spring Statistics

Exported statistics are for SPRING traffic and exclude RSVP and LDP-signaled traffic. Family MPLS statistics per interface are accounted for separately. The segment routing statistics also include SPRING traffic statistics per link aggregation group (LAG) member and per segment identifier (SID).

Use a valid SPRING configuration

Statistics are not collected without the appropriate SPRING configuration in place. Before enabling SPRING statistics, verify your SPRING configuration on the device you will use to export statistics. Below is a sample Junos OS SPRING configuration.

Ingress Device

```
user@host# set groups isis protocols isis traffic-engineering family inet shortcuts
user@host# set groups isis protocols isis source-packet-routing sensor-based-stats per-sid
ingress
user@host# set groups isis protocols isis source-packet-routing srgb start-label 400
user@host# set groups isis protocols isis source-packet-routing srgb index-range 20000
user@host# set groups isis protocols isis source-packet-routing node-segment ipv4-index 1
user@host# set groups isis protocols mpls traffic-engineering bgp-igp-both-ribs
```

```
user@host# set groups isis protocols isis traffic-engineering family inet shortcuts
user@host# set groups isis protocols isis traffic-engineering family inet-mpls shortcuts
```

Transit Device

```
user@host# set groups isis protocols isis traffic-engineering family inet shortcuts
user@host# set groups isis protocols isis source-packet-routing sensor-based-stats per-sid
ingress
user@host# set groups isis protocols isis source-packet-routing srgb start-label 400
user@host# set groups isis protocols isis source-packet-routing srgb index-range 20000
user@host# set groups isis protocols isis source-packet-routing node-segment ipv4-index 2

user@host# set groups isis system services extension-service request-response grpc clear-text
port 32767
user@host# set groups isis system services extension-service request-response grpc max-
connections 8
user@host# set groups isis system services extension-service request-response grpc skip-
authentication
```

Egress Device

```
user@host# set groups isis protocols isis traffic-engineering family inet shortcuts
user@host# set groups isis protocols isis source-packet-routing sensor-based-stats per-sid
ingress
user@host# set groups isis protocols isis source-packet-routing srgb start-label 400
user@host# set groups isis protocols isis source-packet-routing srgb index-range 20000
user@host# set groups isis protocols isis source-packet-routing node-segment ipv4-index 3
```

For more information about configuring SPRING, see *Understanding Source Packet Routing in Networking (SPRING)*.

Enable Export of Statistics

To receive statistics, enable statistical data for export on Juniper device through the Junos OS. To enable export, configure **per-sid-ingress** at the [**edit protocols isis source-packet-routing**] hierarchy level. For example, see "Enabling Collection of SPRING Statistics and Exporting Them" on page 181.

Export Statistics

After you have enabled telemetry export for transit SPRING statistics, stream statistics to an outside collector using either remote procedure call (gRPC) services or a native sensor. Native sensors exports statistics in UDP-format and requires a Junos OS configuration on the device.

SEE ALSO

Understanding Source Packet Routing in Networking (SPRING)

Enable Collection and Export of SPRING Statistics | 181

Enable Collection and Export of SPRING Statistics

Enable statistics for collection before exporting them. After enabling statistics for collection, choose how to export them to an external collector using either gRPC services or a UDP format with a native sensor.

To enable the export of transit SPRING statistics:

Enable sensor-based statistics per segment identifier for the ingress direction:

```
[edit protocols isis source-packet-routing]
user@host# set sensor-based-stats per-sid ingress
```

To export transit SPRING statistics using gRPC services:

1. Start gRPC services for the device by including the configuration below:

```
system {
    services {
        extension-service {
            request-response {
                grpc {
                    clear-text {

                        port 32767;
                    }
```

```
                    skip-authentication;
                }
            }
        }
    }
}
```

2. Create a subscription using the telemetrySubcribe remote procedure call. The subscription must contain telemetry parameters, including the resource path **/junos/services/segment-routing/sid/usage/**. For more information about configuring gRPC streaming and creating a subscription for statistics to be delivered to an outside collector, see "Understanding Junos Telemetry " on page 2, *Configure gRPC Services*, and *Configure a NETCONF Proxy Telemetry Sensor in Junos*.

To export transit SPRING statistics in UDP-format using a native sensor:

1. Configure the *sensor* statement at the `[edit services analytics]` hierarchy level on the device. Include the sensor path (**/junos/services/segment-routing/sid/usage/**), an export profile name, a resource identifier string that enables monitoring and streaming of data for the specified system resource, and a server name to collect the data.

For more information about configuring a native sensor, see "Configure a Sensor Profile" on page 100.

SEE ALSO

Understanding Source Packet Routing in Networking (SPRING)

Change History Table

Feature support is determined by the platform and release you are using. Use Feature Explorer to determine if a feature is supported on your platform.

Release	Description
19.1R1	Starting in Junos OS Release 19.1R1, Junos Telemetry supports the export of transit SPRING statistics on PTX3000 routers and PTX5000 routers with FPC2

Configuring IP-AFT Prefix Filtering

In the OpenConfig Abstract Forwarding Table (OC-AFT) model, the Forwarding Information Base Telemetry Daemon (FIBTD) not only translates the FIB state to the external collector, but also enables you to configure prefix filtering on the target device (source). With prefix filtering, you control the flow of data from your device to the collector. Only interfaces with the required prefixes and their corresponding next-hop and next-hop group containers are exported to the OC-AFT collector.

Reducing the set of interfaces to only those with prefixes of interest decreases the overall CPU and resource usage on Routing Engines, FPCs, and MPCs.

To configure prefix filtering:

1. In configuration mode, go to the `[edit system fib-streaming]` hierarchy level and add the forwarding information base (FIB) table you want to target using the `table` statement.

   ```
   [edit]
   user@host# set system fib-streaming prefix-list table FIB1
   ```

2. Include the `family` statement and specify either `inet` (IPv4) or `inet6` (IPv6).

   ```
   [edit system fib-streaming prefix-list table FIB1]
   user@host# set family inet6
   ```

3. Use the `prefix` statement to add the address prefix following; here, the address is `2001:db8:0000:0000:250:af:34ff:fe26/64` and the prefix is `2001:db8:0000:0000:250:af:34ff:fe26/64`

   ```
   [edit system fib-streaming prefix-list table FIB1 family inet6]
   user@host# set prefix 2001:db8:0000:0000:250:af:34ff:fe26/64
   ```

4. In Junos OS, to verify if prefix filtering is configured, use the operational mode command `show fib-streaming state` to display the `Operation mode`. The value `prefix-filter` confirms that prefix filtering mode is enabled.

   See below the sample show command output in Junos OS:

   ```
   user@host> show fib-streaming state
   Jun 03 22:45:43
               FIB states resync: 1
               RPD client session state: Connected
               LSP name init sync done: 1
               Resync done: 1
               Operation mode: prefix-filter
   ```

   In Junos OS Evolved, the value `prefix-filter-on-change` confirms that prefix filtering mode is enabled, else the value is `on-change` for non-prefix filtering mode.

NOTE: **For Junos OS**: Export data from your source (target) to a collector using the sensor **/network-instances/network-instance/afts/**. When using prefix-filter mode, we recommend you use streaming subscription mode at a sampling frequency of 5 minutes or more. Ensure that all collectors have the same sampling frequency. If you are using non-prefix-filter mode, we recommend you use ON_CHANGE subscription mode. You can also export data using User Datagram Protocol (UDP).

For Junos OS Evolved: Use ON_CHANGE subscription mode, for both prefix-filtering and non-prefix filtering mode.

RELATED DOCUMENTATION

prefix-list (Junos Telemetry Interface)

show fib-streaming state

gRPC Service | 22

Configure a NETCONF Proxy Telemetry Sensor in Junos

Enable Subscriber and Service Accounting for BNG CUPS Telemetry

Junos Telemetry streams accounting statistics on the Juniper® BNG CUPS (Broadband Network Gateway Control and User Plane Separation) Controller by subscribing to the `subscriber` sensor. The statistics information includes actual subscriber transit statistics, firewall filter statistics, and subscriber metadata.

Use the following configuration statements to enable telemetry support for subscriber metadata:

1. Specify the `subscriber-info` configuration statement to enable streaming of subscriber metadata to an external telemetry server when the subscriber logs into or logs out of the device under test (DUT).

   ```
   set dynamic-profiles CLIENT-PROFILE telemetry subscriber-info
   ```

2. Specify the `subscriber-statistics` option to allow periodic streaming of subscriber accounting statistics such as input packets/octets and output packets/octets to an external telemetry server.

   ```
   set dynamic-profiles CLIENT-PROFILE telemetry subscriber-info subscriber-statistics
   ```

3. Specify the `service-statistics` option to allow periodic streaming of firewall filter statistics for IPv4 and IPv6 filters to an external telemetry server.

   ```
   set dynamic-profiles FILTER-PROFILE telemetry subscriber-info service-statistics
   ```

The `subscriber-info` hierarchy level contains the configuration commands to enable telemetry for subscriber and service statistics. These commands were previously under the `dynamic-profiles` hierarchy.

Use the following command to check the sensor subscription:

```
user@host> show agent sensors
Sensor Information Sensor name     :__default_fabric_sensor__
        Resource         :/junos/system/linecard/fabric
        Object ID       :2277069355
        Sensor ID      :9288676508521003
        Polling Interval    :2000000000
Server Information Server name     :__default__snmp_server__
        Server ID :33
        Scope ID :0
        Remote-Address :0.0.0.0
        Remote-port :0
Profile Information: Profile
name     :__default_snmp_export_profile__
        profile ID :1
        Rep-interval :2000
        Local-Address :0.0.0.0
        Local-port :0
        Timestamp :0
        Format :1
        Transport :0
Sensor Information Sensor name :ddos
        Resource :/junos/system/linecard/ddos/
        Object ID :3440566888
        Sensor ID :21110626693866088
        Polling Interval :1000
        Server Information Server
            name :sserver
    Server ID :75
        Scope ID :0 Remote-
Address :10.0.0.1
Remote-port :2000
Local-Address         :10.0.0.10
        Local-port     :21111
        Timestamp         :1
        Format         :1
        Transport         :0
```

The following table describes the sensor subscription path and their data models:

Table 18: Data models and sensor subscription paths

Data Exported	Sensor Path	Usage Group	Data Model
Subscriber information	*/junos/system/subscriber-management/cups/cp-instances/cp-instance/subscribers/subscriber-info*	*interface-information* group	Uses the data model as in Integrated BNG, except data streamed is CP specific. There are additional fields added to the *interface-information* group: **PeerSid** – This field gives the session ID on the user plane. **User-plane:port** – This field gives the user plane name and port on which the session has come up. **SGRP Name**– This field gives the SGRP (subscriber group) name of the session. **Device ID**– This field gives the device ID of the session.
Subscriber statistics	*/junos/system/subscriber-management/cups/cp-instances/cp-instance/subscribers/accounting-statistics*	*actual-transit-statistics* group	The data model remains same as subscriber-statistics in integrated BNG, except for the sensor subscription path.
Service statistics	*/junos/system/subscriber-management/cups/cp-instances/cp-instance/subscribers/service-statistics*	*service-filter-statistics* group	The data model remains same as service-statistics in integrated BNG, except for the sensor subscription path.

Junos Telemetry exports all the above sensor data to an external collector through telemetry for each control plane.

The configuration hierarchy for the `dynamic-profiles` statement is as follows.

```
telemetry {
                subscriber-info {
                          subscriber-statistics;
                          service-statistics;
                      }
                 queue-statistics {
                     interface $junos-interface-name {
                         refresh rate;
                         queues queue set;
                     }
                     interface-set $junos-interface-set-name {
                          refresh rate;
                          queues queue set;
                     }
                 }
                }
```

NOTE: The `subscriber-info` configuration statement is mandatory under telemetry. Within the `subscriber-info` statement, there are two optional configurations: `service-statistics` and `subscriber-statistics`.

RELATED DOCUMENTATION

subscriber-info

https://apps.juniper.net/ydm-explorer/

Interface Burst Monitoring

Junos OS Evolved Release 19.3R1 supports interface burst monitoring on Junos Telemetry. Interface burst monitoring tracks physical interfaces for bursts on Juniper Networks® QFX5220-128C Switch and Juniper Networks® QFX5220-32CD Switch. Use interface burst monitoring to help troubleshoot problems, make decisions, and adjust resources as needed.

Sampling uses millisecond granularity during the export interval (window). onfigure the export interval in the sensor with the subscription from the collector. When you install the sensor, the Packet Forwarding Engine starts a timer to poll the hardware in 30 ms through 100 ms intervals. Rates in the first export batch are "0".

The peak byte is the average of the number of bytes seen in a sampling interval. For bursts lasting less than the sampling interval, the peak byte is averaged out over the interval. Exported statistics also include the time peak bytes are detected and the direction (transmit or receive). he maximum byte rate detected among all samples in the export interval is the burst. If there are multiple bursts of the same number of bytes rate in the interval, then the first occurring burst is considered as the maximum burst and the timestamp of that burst is considered as the burst timestamp.

Data for all physical interfaces that are "UP" is exported. Aggregate interfaces are not supported.

Export interface burst statistics from the Juniper device to an outside collector by including the sensor **/junos/system/linecard/bmon-sw/** in a subscription using remote procedure call (gRPC) services. Only one collector is supported with this sensor.

To provision the sensor to export data through gRPC services, use the `telemetrySubscribe` RPC to specify telemetry parameters. Streaming telemetry data through gRPC also requires the OpenConfig for Junos OS module.

NOTE: This feature does not detect microbursts.

Sensor Power-State Management Support Using gNMI

You can use gNMI to manage the power state of the Routing Engines (controller cards) on a dual Routing Engine system. You can configure a Routing Engine to power off and remain powered off by using gNMI to set the OpenConfig path`/components/component/controller-card/config/power-admin-state` value to **POWER_DISABLED**.

When you configure the power state of the backup Routing Engine (secondary controller card) as **POWER_DISABLED**, the configuration takes effect immediately. The device powers off the Routing Engine and sets the `config/power-admin-state` to **POWER_DISABLED**. The Routing Engine remains powered off even through reboots. Similarly, setting the power state to **POWER_ENABLED** immediately brings the Routing Engine back online.

If you configure the power state of the primary Routing Engine as **POWER_DISABLED**, the configuration takes effect upon the next reboot or switchover. However, configuring

POWER_DISABLED on the primary Routing Engine automatically triggers a switchover. Thus, after the primary Routing Engine assumes the backup role, it immediately powers off.

Consider the following rules before making changes to the power-admin-state of your device:

- Only controller cards in the **SECONDARY** `state/redundant-role` honor changes in the `config/power-admin-state` to **POWER_DISABLED**.
- On controller cards in the **PRIMARY** `state/redundant-role`, if you try to set `config/power-admin-state` to **POWER_DISABLED**, the operation is allowed. However, the `state/power-admin-state` may remain as **POWER_ENABLED** until the next switchover or reboot.
- The system initiates a switchover to change the role of **PRIMARY** to **SECONDARY** as soon as you configure the active Routing Engine as **POWER_DISABLED**.

A gNMI client can configure a Routing Engine to remain powered off, for example:

```
gnmic -a hostname:port -u user -p password --tls-ca /path/to/serverRootCA --update-path /
components/component[name=node]/controller-card/config/power-admin-state/ --update-value
"POWER_DISABLED" --timeout timeout
```

The following example uses the gNMI client `gnmic` to send a `SetRequest` to update the `config/power-admin-state` value to `POWER_DISABLED` for the backup Routing Engine (RE1):

```
user@client:~$ gnmic -a 10.1.1.2:32767 -u grpc-user -p password --tls-ca /etc/pki/certs/
serverRootCA.crt set --update-path /components/component[name=RE1]/controller-card/config/power-
admin-state/ --update-value "POWER_DISABLED" --timeout 30s
{
  "source": "10.1.1.2:32767",
  "timestamp": 1739315808281370579,
  "time": "2025-02-11T15:16:48.281370579-08:00",
  "results": [
    {
      "operation": "UPDATE",
      "path": "openconfig:components/component[name=RE1]/controller-card/config/power-admin-
state"
    }
  ]
}
```

Verify the configuration.

```
user@host> show configuration openconfig-platform:components
component RE1 {
    controller-card {
        config {
            openconfig-platform-controller-card:power-admin-state POWER_DISABLED;
        }
    }
}
```

The OpenConfig configuration is equivalent to issuing the `set system node offline` *`node`* configuration mode command in the Junos OS Evolved configuration.

Use the `show system nodes` operational mode command to verify that the state of the Routing Engine is offline.

```
user@host> show system nodes re1
Node: re1
  Node Id    : 0
  Node Nonce : 0
  Status     : offline, configured-offline
  Attributes :
```

Similarly, you can re-enable the Routing Engine.

```
gnmic -a hostname:port -u user -p password --tls-ca /path/to/serverRootCA --update-path /
components/component[name=node]/controller-card/config/power-admin-state/ --update-value
"POWER_ENABLED" --timeout timeout
```

The following example uses the gNMI client `gnmic` to send a `SetRequest` to update the `config/power-admin-state` value to `POWER_ENABLED` for the backup Routing Engine (RE1) :

```
user@client:~$ gnmic -a 10.1.1.2:32767 -u grpc-user -p password --tls-ca /etc/pki/certs/
serverRootCA.crt set --update-path /components/component[name=RE1]/controller-card/config/power-
admin-state/ --update-value "POWER_ENABLED" --timeout 30s
{
  "source": "10.1.1.2:32767",
  "timestamp": 1739315506688244303,
  "time": "2025-02-11T15:11:46.688244303-08:00",
```

```
  "results": [
    {
      "operation": "UPDATE",
      "path": "openconfig:components/component[name=RE1]/controller-card/config/power-admin-
state"
    }
  ]
}
```

When you update the `config/power-admin-state` to `POWER_ENABLED`, the Routing Engine is brought online.

```
user@host> show system nodes re1
Node: re1
  Node Id    : 2201170739205
  Node Nonce : 2159053780
  Status     : online, apps-ready
  Attributes : FABRIC_CONTROL (Spare), FABRIC_FCHIP_PARALLEL (Spare), PFE_TOKEN (Spare), RE
(Spare), TIMINGD_RE (Spare), BackupRE (Active)
```

Resource Filtering

SUMMARY

The resource filtering feature selectively exports telemetry data from specific network device components and reduces bandwidth usage and processing time.

IN THIS SECTION

On a fully loaded network device with thousands of IFLs and IFDs, retrieving data for all IFLs and IFDs can require multiple attempts and consume significant bandwidth. Resource filtering enables a collector to choose only the data the collector requires from a specific resource. This feature supports XPATH based resource filtering for AFT platforms and REGEX based filtering for PFE sensors on Junos microkernel.

Benefits of Resource Filtering

- You can select or reject specific instances of a resource, such as a key. This can include data from a particular IFL/IFD or all IFLs/IFDs.
- You can use a wildcard option to selectively choose resources for an element.

Types of Resource Filtering

- **XPATH-based filtering-** XPATH based filtering uses a key field or wildcard of one or more paths. The following options are supported in the XPATH based resource filtering:
  - Precise path or keys. Example: `/interfaces/interface[name=xe-0/0/0]`
  - Full wildcard of keys. Example: `/interfaces/interface[name=*]`
  - Partial wildcard of keys. Example: `/interfaces/interface[name=xe-0/0/*]`
  - Multi-level key options. i.e., data pertaining to a particular IFL or an IFD.
- **REGEX-based filtering-** REGEX filtering uses only a key field. Many options let you select a key, such as:
  - Precise path `xe-0/0/0`
  - Starts with `xe-0/*`
  - Ends with `*/0/0`
  - Not a particular interface `!xe-0/0/0`

NOTE:

- XPATH-based resource filtering is not applicable to UDP mode of transport.
- gNMI resource filtering and wild card filtering options are not applicable for firewall configuration path `/junos/system/linecard/firewall`. No method passes resource filter information in that path.

Example Configurations from a Collector

- **Precise path or key such as `/interfaces/interface[name=xe-0/0/0`:**

  An example configuration for a precise path or a key is as follows for gRPC:

```
{
  "dut_list":
           [
            {
              "ip": "ferrari-mx02",
              "port":50051,
              "session_log":"grpc.session",
              "log_head":"grpc.data",
              "oc_rpc" : ["subscribe"],
              "subscribe": {
                              "path_list": [{ "path":"/interfaces/
interface[name='et-0/0/0']", "filter":"", "sample_frequency":2000, "suppress_unchanged":"",
"max_silent_interval":0}],
                              "input":{"collector_list":[{"address":"13.1.1.1"}]},
                              "additional_config":{"limit_records":1, "limit_time_seconds":1}
                        }
            }
           ]
}
```

- **Full wildcard of keys such as `/interfaces/interface`**

  A sample configuration for a wildcard of keys is as follows for gRPC:

```
{
  "dut_list":
           [
            {
              "ip": " ferrari-mx02",
              "port":50051,
              "session_log":"grpc.session",
              "log_head":"grpc.data",
              "oc_rpc" : ["subscribe"],
              "subscribe": {
                              "path_list": [{ "path":"/interfaces/interface/", "filter":"",
"sample_frequency":2000, "suppress_unchanged":"", "max_silent_interval":0}],
```

```
                              "input":{"collector_list":[{"address":"13.1.1.1"}]},
                              "additional_config":{"limit_records":1, "limit_time_seconds":1}
                        }
            }
           ]
}
```

- **Partial wildcard of a key such as `/interfaces/interface[name='et-0/0/*']`**

  A sample configuration for a partial wildcard of path is as follows:

```
{
  "dut_list":
           [
            {
              "ip": "ferrari-mx02",
              "port":50051,
              "session_log":"grpc.session",
              "log_head":"grpc.data",
              "oc_rpc" : ["subscribe"],
              "subscribe": {
                              "path_list": [{ "path":"/interfaces/interface[name='et-0/0/*']
", "filter":"",
"sample_frequency":2000, "suppress_unchanged":"", "max_silent_interval":0}],
                              "input":{"collector_list":[{"address":"13.1.1.1"}]},
                              "additional_config":{"limit_records":1, "limit_time_seconds":1}
                        }
            }
           ]
}
```

- **gNMI Configuration**

  A sample gNMI configuration is as follows:

```
{
    "host": "gamoral-intf-mtt1-c",
    "user": "regress",
    "password": "MaRtInI",
    "port": 50051,
    "cid": "cid-45",
    "gnmi": {
```

```
        "mode": 0,
        "encoding": 2
    },
    "grpc": {
        "ws": 1048576
    },
    "paths": [
        {
            "path": "/interfaces/interface[name='et-0/0/31']/",
            "freq": 2000000000,
            "gnmi_submode": 2
        }
    ]
}
```

- **Firewall related such as a precise key filter":"__default_arp_policer__"**

  As this is a Junos path, use the `filter` option in the Json file.

```
{
  "dut_list":
           [
            {
              "ip": "ferrari-mx01",
              "port":50051,
              "session_log":"session.healthz_modify",
              "log_head":"data.ferrari_mx01",
              "oc_rpc" : ["subscribe"],
              "subscribe": {
                              "path_list": [{ "path":"/junos/system/linecard/firewall/",
"filter":"__default_arp_policer__", "sample_frequency":2000, "suppress_unchanged":"",
"max_silent_interval":0}],
                              "input":{"collector_list":[{"address":"10.213.2.16",
"port":50051}]},
                              "additional_config":{"limit_records":1, "limit_time_seconds":1,
"need_eos": 1}
                           }
            }
           ]
}
```

- **Firewall related such as a partial wildcard key filter":"__default_arp_*"**

A sample configuration is as follows:

```
{
  "dut_list":
           [
            {
              "ip": "ferrari-mx01",
              "port":50051,
              "session_log":"session.healthz_modify",
              "log_head":"data.ferrari_mx01",
              "oc_rpc" : ["subscribe"],
              "subscribe": {
                              "path_list": [{ "path":"/junos/system/linecard/firewall/",
"filter":"__default_arp_*", "sample_frequency":2000, "suppress_unchanged":"",
"max_silent_interval":0}],
                              "input":{"collector_list":[{"address":"10.213.2.16",
"port":50051}]},
                              "additional_config":{"limit_records":1, "limit_time_seconds":1,
"need_eos": 1}
                           }
            }
           ]
}
```

- **Firewall related such as no filter ---- filter":""**
  In this case, data pertaining to all keys are exported.

```
{
  "dut_list":
           [
            {
              "ip": "ferrari-mx01",
              "port":50051,
              "session_log":"session.healthz_modify",
              "log_head":"data.ferrari_mx01",
              "oc_rpc" : ["subscribe"],
              "subscribe": {
                              "path_list": [{ "path":"/junos/system/linecard/firewall/",
"filter":"", "sample_frequency":10000, "suppress_unchanged":"", "max_silent_interval":0}],
                              "input":{"collector_list":[{"address":"10.213.2.16",
"port":50051}]},
```

```
                                "additional_config":{"limit_records":1, "limit_time_seconds":1,
"need_eos": 1}
                             }
             }
            ]
}
```

NOTE: If you add a new filter, an IFL, or an IFD and use a filter option in the telemetry subscription, the system applies the filter option to the newly added filter, IFL, or the IFD.

5

PART

Sensor-Specific Supplementary Information

Leaf-Level Support for PFE Sensors

SUMMARY

You can configure leaf-level resource paths for telemetry data export on network devices to reduce computational overhead and bandwidth usage. This feature allows selective querying of specific data elements, such as interface operational status or packet counters, instead of exporting data for all instances of a resource. By focusing on relevant leaves, you obtain precise information efficiently, enhancing performance for telemetry collectors.

Using this leaf-level support feature, any path up to a given element can be configured and only data corresponding to that element is exported.

The following XPATH leaf options are supported:

- Precise leaf such as `/interfaces/interface[name='et-1/0/35']/state/counters/in-pkts`
- A container within the path such as `/interfaces/interface[name='et-1/0/35']/state/counters/`
- A list within the path `/interfaces/interface/`
- Exported leafs for IFD/IFL/Queues

The full list of leaves exported for physical, logical interfaces and the associated queues.

- **IFD or Physical Interfaces**

```
interfaces/interface/state/counters/in-pkts
interfaces/interface/state/counters/in-octets
interfaces/interface/state/counters/in-unicast-pkts
interfaces/interface/state/counters/in-broadcast-pkts
interfaces/interface/state/counters/in-multicast-pkts
interfaces/interface/state/counters/in-pause-pkts
interfaces/interface/state/counters/in-discards
interfaces/interface/state/counters/in-errors
interfaces/interface/state/counters/in-unknown-proto-pkts
interfaces/interface/state/counters/out-pkts
interfaces/interface/state/counters/out-octets
interfaces/interface/state/counters/out-unicast-pkts
interfaces/interface/state/counters/out-broadcast-pkts
```

```
interfaces/interface/state/counters/out-multicast-pkts
interfaces/interface/state/counters/out-pause-pkts
interfaces/interface/state/counters/out-discards
interfaces/interface/state/counters/out-errors
interfaces/interface/state/counters/out-unknown-proto-pkts
```

- IFD Queues

```
interfaces/interface/state/counters/out-queue/queue-number
interfaces/interface/state/counters/out-queue/pkts
interfaces/interface/state/counters/out-queue/bytes
interfaces/interface/state/counters/out-queue/tail-drop-pkts
interfaces/interface/state/counters/out-queue/tail-drop-bytes
interfaces/interface/state/counters/out-queue/rl-drop-pkts
interfaces/interface/state/counters/out-queue/rl-drop-bytes
interfaces/interface/state/counters/out-queue/red-drop-pkts
interfaces/interface/state/counters/out-queue/red-drop-bytes
interfaces/interface/state/counters/out-queue/avg-buffer-occupancy
interfaces/interface/state/counters/out-queue/cur-buffer-occupancy
interfaces/interface/state/counters/out-queue/peak-buffer-occupancy
interfaces/interface/state/counters/out-queue/allocated-buffer-size
```

- IFL or Logical Interfaces

```
interfaces/interface/subinterfaces/subinterface/state/counters/in-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-octets
interfaces/interface/subinterfaces/subinterface/state/counters/out-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/out-octets
interfaces/interface/subinterfaces/subinterface/state/counters/in-unicast-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-multicast-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/out-unicast-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/out-multicast-pkts
```

- IFL Queues

```
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/queue-number
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/bytes
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/tail-drop-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/tail-drop-bytes
```

```
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/rl-drop-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/rl-drop-bytes
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/red-drop-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/red-drop-bytes
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/avg-buffer-occupancy
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/cur-buffer-occupancy
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/peak-buffer-occupancy
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/allocated-buffer-size
interfaces/interface/subinterfaces/subinterface/state/counters/out-queue/queue-number
interfaces/interface/subinterfaces/subinterface/state/counters/out-queue/pkts
interfaces/interface/subinterfaces/subinterface/state/counters/out-queue/bytes
interfaces/interface/subinterfaces/subinterface/state/counters/out-queue/tail-drop-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/rl-drop-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/rl-drop-bytes
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/red-drop-pkts
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/red-drop-bytes
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/avg-buffer-occupancy
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/cur-buffer-occupancy
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/peak-buffer-occupancy
interfaces/interface/subinterfaces/subinterface/state/counters/in-queue/allocated-buffer-size
interfaces/interface/subinterfaces/subinterface/state/counters/out-queue/queue-number
interfaces/interface/subinterfaces/subinterface/state/counters/out-queue/pkts
interfaces/interface/subinterfaces/subinterface/state/counters/out-queue/bytes
interfaces/interface/subinterfaces/subinterface/state/counters/out-queue/tail-drop-pkts
```

NOTE:

- Leaf level support is applicable to both gRPC and gNMI transport modes.
- Leaf level subscription is not supported for leaves where configuration and exported paths are different.

CPU and NPU Sensor Support for MX Series Routers with MPC10E-15C-MRATE Line Cards

Junos OS Release 19.3R1 supports CPU and network processing unit (NPU) sensors on MX Series routers with MPC10E-10C-MRATE and MPC10E-15C-MRATE line cards. Junos Telemetry enables the export of statistics from these sensors to outside collectors at configurable intervals using gRPC services.

Unlike the Junos kernel implementation for the CPU and NPU sensors in previous Junos releases, this feature uses the OpenConfig AFT model. Because of this, there is a difference in the resource path and key-value (kv) pair output compared to the Junos kernel output.

Use the following resource path to export statistics:

- **/junos/system/linecard/cpu/memory/**
- **/junos/system/linecard/npu/memory/**
- **/junos/system/linecard/npu/utilization/**

To provision the sensor to export data through gRPC services, use the `telemetrySubcribe` RPC to specify telemetry parameters. Streaming telemetry data through gRPC requires the OpenConfig for Junos OS module.

For more information about resource paths, see "Explore Sensor Paths" on page 9.

Delivery of Telemetry Data for AFT-Based Line Cards on MX Series Routers

Starting with Junos OS Release 20.4R1, a new implementation for prefix-and-key-delivery for telemetry on Modular Port Concentrator (MPC) line cards supporting Abstract Forwarding Table (AFT) (such as MPC10E or MPC11E line cards). The OpenConfig path is split differently from the syntax on other line cards.

The subsequent output illustrates changes in prefix-and-key-delivery:

```
Example jtimon output for a port on non-AFT LC
key: __prefix__
str_value: /junos/firewall[name='CORERO-MITIGATE-xe-1/0/0.4051-i']/state/
key: counter[name='Corero-Allowed-xe-1/0/0.4051-i']/packets
uint_value: 2935220

<<RESULT>>
path: /junos/firewall[name='CORERO-MITIGATE-xe-1/0/0.4051-i']/state/counter[name='Corero-Allowed-
xe-1/0/0.4051-i']/packets
uint_value: 2935220
```

```
Example jtimon output for a port on an AFT LC
key: __prefix__
str_value: /junos/firewall[name='CORERO-MITIGATE-et-2/0/0.114-i']/state/counter[name='Corero-
Allowed-et-2/0/0.114-i']/
key: packets
uint_value: 29191907

<<RESULT>>
path: /junos/firewall[name='CORERO-MITIGATE-et-2/0/0.114-i']/state/counter[name='Corero-Allowed-
et-2/0/0.114-i']/packets
uint_value: 29191907
```

Diameter Application Protocol And Diameter Peer Sensors For Subscribers

Junos Telemetry supports streaming statistics for subscribers for the diameter application protocols Network Access Server Application (NASREQ), policy and charging rules function (PCRF), and Online Charging System (OCS). New diameter peer sensors also provide response time measurements for messages exchanged between an MX router and the peer for each diameter application. Statistics are exported using Junos telemetry and the Juniper AAA Model, which covers telemetry export using gRPC, gNMI, or Juniper proprietary RPC or UDP.

To stream diameter application statistics, include the resource paths:

- For NASREQ statistics, **/junos/system/subscriber-management/aaa/diameter/clients/nasreq**
- For PCRF statistics, **/junos/system/subscriber-management/aaa/diameter/clients/gx**
- For OCS statistics, **/junos/system/subscriber-management/aaa/diameter/clients/gy**

To stream response time measurements for the diameter applications, include the resource paths in a subscription or using the `sensor` configuration statement:

- For NASREQ measurements, **/junos/system/subscriber-management/aaa/diameter/peers/ peer[peer_address='*peer-address*']/nasreq/response-time**
- For PCRF measurements, **/junos/system/subscriber-management/aaa/diameter/peers/ peer[peer_address='*peer-address*']/gx/response-time**

- For OCS measurements, **/junos/system/subscriber-management/aaa/diameter/peers/ peer[peer_address='*peer-address*']/gy/response-time**

To enable the diameter application statistics for an MX Series router for native (UDP) export, include the `sensors` statement at the [`edit services analytics`] hierarchy level.

To provision the sensor to export data through gNMI, use the Subscribe RPC defined in the gnmi.proto to specify request parameters.

To provision the sensor to export data through gRPC, use the `telemetrySubscribe` RPC to specify telemetry parameters. Streaming telemetry data through gRPC also requires the OpenConfig for Junos OS module.

Junos OS Release 19.3R1 supports diameter application protocol sensors for MX5, MX10, MX40, MX150, MX204, MX240, MX480, MX960, MX2008, MX2010, MX2020, MX10003, MX10008, and MX100016 routers.

For more information about resource paths, see "Explore Sensor Paths" on page 9.

Dynamic Tunnel Statistics Support

Starting with Junos OS Release 17.4R1, you can export counter statistics for Packet Forwarding Engine dynamic tunnels to an outside collector. Use either native (UDP) or OpenConfig telemetry sensors through Junos Telemetry.

The statistics report various network element performance metrics in a scalable, efficient way and provide visibility into Packet Forwarding Engine errors and drops.

All exported data includes a timestamp indicating when the counters were last reset. Collectors can use the timestamp to determine if and when a reset event happened. For example, if the Packet Forwarding Engine hardware restarts.

Exported statistics are similar to the output of the operational mode command `show nhdb hw dynamic-ip-tunnels`.

To provision statistics export through gRPC, use the telemetrySubcribe RPC to create a subscription and specify telemetry parameters. Include the resource path **/junos/services/ip-tunnel[name='tunnel-name']/usage/counters[name='counter-name']/** in the subscription.

Streaming telemetry data through gRPC also requires the OpenConfig for Junos OS module.

To configure the export of statistics through UDP, include the `/junos/services/ip-tunnel/usage/` in the sensor (Junos Telemetry Interface) sensor in the (Junos Telemetry Interface) configuration statement. Place it at the [`edit services analytics`] hierarchy level. All parameters for UDP sensors are configured at that hierarchy level. MX80 and MX104 routers support only UDP streaming. They do not support gRPC.

Standby Routing Engine Sensors For Subscribers

Junos Telemetry supports streaming standby Routing Engine statistics using gRPC services. This feature is supported on both single chassis and virtual chassis unless otherwise indicated. Use this feature to better track the state of software components running on a standby Routing Engine. Statistics exported to an outside collector through the following sensors (primarily under subscriber management) provide a detailed view of the system health and resiliency state:

- Chassis role (backup or primary) sensor **/junos/system/subscriber-management/chassis** and **/junos/system/subscriber-management/chassis[chassis-index=*chassis-index*]** (for specifying an index for an MX Series Virtual Chassis)

- Routing Engine status and GRES notification sensor **/junos/system/subscriber-management/chassis/routing-engines/routing-engine** and **/junos/system/subscriber-management/chassis/routing-engines/routing-engine[re-index=*RoutingEngineIndex*]** (to specify an index number for a specific Routing Engine)

- Subscriber management process sensor **/junos/system/subscriber-management/chassis/routing-engines/process-status/subscriber-management-processes/subscriber-management-process** and **/junos/system/subscriber-management/chassis/routing-engines/process-status/subscriber-management-processes/subscriber-management-process[pid=*ProcessIdentifier*]** (to specify a PID for a specific process)

- Per Routing Engine DHCP binding statistics for server or relay sensor **/junos/system/subscriber-management/chassis/routing-engines/routing-engine/dhcp-bindings/dhcp-element[dhcp-type-name=*RelayOrServer*/v4]** and **/junos/system/subscriber-management/chassis/routing-engines/routing-engine/dhcp-bindings/dhcp-element[dhcp-type-name=*RelayOrServer*/v6]**

- Virtual Chassis port counter sensor **/junos/system/subscriber-management/chassis/virtual-chassis-ports/virtual-chassis-port** and **/junos/system/subscriber-management/chassis/virtual-chassis-ports/virtual-chassis-port[vcp-interface-name=*vcp-interface-port-string*] (to specify the interface name)**. This resource path is only supported on a virtual chassis.

Junos OS Release 20.2R1 supports standby Routing Engine sensors for MX480, MX960, MX10003, MX2010, and MX2020 routers.

For more information about resource paths, see "Explore Sensor Paths" on page 9.

Enabling Streaming of Telemetry Sensor Information for SR-TE policies (BGP or Static)

Starting with Junos OS Release 18.3R1, OpenConfig support for MX Series and PTX Series through gRPC and Junos Telemetry provides continuous statistics streaming via the same sensor irrespective of the route that is active (BGP or static) for a given Segment Routing Traffic Engineering (SR-TE) policy.

Support is available in Junos OS Evolved Release 21.4R1EVO for PTX10001-36MR, PTX10004, PTX10008, and PTX10016 routers.

This feature provides support for BGP [DRAFT-SRTE] and statically configured SR-TE policies at ingress routers.

To provision the sensor to export data through gRPC streaming, use the telemetrySubscribe RPC to specify telemetry parameters. Include the resource path `/mpls/signaling-protocols/segment-routing/` to export these statistics.

In addition to configuring the sensor, you must enable statistics collection through the Junos OS. To do this, include the `statistics` configuration statement at the [`edit protocols source-packet-routing telemetry`] hierarchy level. Optionally, you can limit statistics by including the `no-transit` or `no-ingress` parameter.

See *Configure a NETCONF Proxy Telemetry Sensor in Junos* for instructions on configuring a sensor.

See "Explore Sensor Paths" on page 9 for further information about resource paths.

FPC and Optics Support

Starting in Junos OS Release 19.2R1, Junos Telemetry enables streaming of Flexible PIC Concentrator (FPC) and optics statistics for the MX Series with gRPC. gRPC is a protocol for configuration and retrieval of state information. Support includes adding the SensorD daemon to export telemetry data for integration with AFT Telemetry and LibTelemetry libraries in the OpenConfig model named AFT platform.

The following base resource paths are supported:

- **/junos/system/linecard/environment/**
- **/junos/system/linecard/optics/**

To provision the sensor to export data through gRPC, use the telemetrySubcribe RPC to specify telemetry parameters. Streaming telemetry data through gRPC also requires the OpenConfig for Junos OS module.

Exporting Packet Forwarding Engine Traffic Sensor Data

Starting with Junos OS Release 17.4R1, you can export Packet Forwarding Engine traffic statistics. Use the Junos Telemetry for Juniper Networks® MX Series Universal Routing Platforms and Juniper Networks PTX Series Routers. Use both UDP and gRPC.

This sensor tracks reporting of Packet Forwarding Engine statistics counters and provides visibility into Packet Forwarding Engine error and drop statistics. The resource name for the sensor is `/junos/system/linecard/packet/usage/`. The OpenConfig paths report data specific to CPU, NPU and center chip (CC). The following paths are supported:

- `/components/component[name='FPC`*id*`:NPU`*id*`']/properties/property[name='`*counter*`']/state/value`, where FPC refers to the Flexible PIC Concentrator and NPU refers to the network processing unit (packet forwarding engine). A sample resource path is `/components/component[name='FPC0:NPU3']/properties/property[name='ts-output-pps']/state/value` where `hwds-data-error` is the counter for `Hardware Discards: Data Error`.

- `/components/component[name='FPC`*id*`:CC`*id*`']/properties/property[name='`*counter*`']/state/value` , where FPC refers to the Flexible PIC Concentrator and CC refers to the center chip. A sample resource path is `/components/component[name='FPC0:CC1']/properties/property[name='lpbk-packets'']/state/value` where `lpbk-packets` is the count of `Forward packets` specific to FPC0, center chip 1.

- `/components/component[name='FPC`*id*`']/properties/property[name='`*counter*`']/state/value` , where FPC refers to the Flexible PIC Concentrator. A sample resource path is `/components/component[name='FPC0']/properties/property[name='lts-input-packets'']/state/value` where `lts-input-packets` is the CPU counter `Local packets input`.

To provision the sensor to export data through gRPC, use the `telemetrySubscribe` RPC to specify telemetry parameters. For streaming through UDP, all parameters are configured at the `[edit services analytics]` hierarchy level.

The following is a map of counters to output fields in the `show pfe statistics traffic` command or `show pfe statistics traffic detail` command (supported only on MX Series routers).

```
CPU stats: (FPCX:CPUY)
Packet Forwarding Engine local traffic statistics:
```

```
    Local packets input              :                    2
    Local packets output             :                    1
    Software input control plane drops  :                 0
    Software input high drops        :                    0
    Software input medium drops      :                    0
    Software input low drops         :                    0
    Software output drops            :                    0
    Hardware input drops             :                    0


Counter
lts-input-packets              Local packets input
lts-output-packets             Local packets output
lts-sw-input-control-drops     Software input control plane drops
lts-sw-input-high-drops        Software input high drops
lts-sw-input-medium-drops      Software input medium drops
lts-sw-input-low-drops         Software input low drops
lts-sw-output-low-drops        Software output drops


NPU stats: (FPCX:CCY)
    Input  packets:                1169                    0 pps
    Output packets:                   0                    0 pps
    Fabric Input  :           277235149                16078 pps
    Fabric Output :           277235149                16079 pps


Counter
ts-input-packets                Input  packets
ts-input-packets-pps            Input  packets in pps
ts-output-packets               Output packets
ts-output-packets-pps           Output packets in pps
ts-fabric-input-packets         Fabric Input
ts-fabric-input-packets-pps     Fabric Input in pps
ts-fabric-output-packets        Fabric Output
ts-fabric-output-packets-pps    Fabric Output in pps

Packet Forwarding Engine loopback statistics:
    Forward packets :                    0                    0 pps
    Forward bytes   :                    0                    0 bps
    Drop packets    :                    0                    0 pps
    Drop bytes      :                    0                    0 bps
```

```
Counter
lpbk-packets                   Forward packets
lpbk-packets-pps               Forward packets pps
lpbk-packets-byte              Forward bytes
lpbk-packets-bps               Forward bytes   bps

lpbk-drop-packets              Drop packets
lpbk-drop-packets              Drop packets pps
lpbk-drop-packets              Drop bytes
lpbk-drop-packets              Drop bytes bps



Lu chips stats: FPCx:NPUY
Counter
lts-hw-input-drops
hwds-normal           Hardware discards normal discard
hwds-fabric           Hardware discards fabric drops
hwds-info-cell        Hardware discards info cell drops
hwds-timeout          Hardware discards timeour
hwds-truncated-key    Hardware discards truncated key
hwds-bits-to-test     Hardware discards bits to test
hwds-stack-underflow  Hardware discards stack underflow
hwds-stack-overflow   Hardware discards stack overflow
hwds-data-error       Hardware discards data error
hwds-extended         Hardware discards extended discard
hwds-invalid-iif      Hardware discards invalid interface
hwds-input-checksum   Hardware discards input checksum
hwds-output-mtu
hwds-inet-bad-route
hwds-inet6-bad-route
hwds-filter-discard
hwds-dlu-not-routable
```

Export Timing Data to Collectors

IN THIS SECTION

Junos Telemetry supports export of timing attributes for Precision Time Protocol (PTP) and Synchronous Ethernet (SyncE) to the collector. The data exported through native models, and the PTP data exported through the YANG model. Both periodic streaming and on-change notifications are supported. Use the following new subscription paths:

- For PTP: `/state/protocols/ptp/instances/instance[instance-index]/`
- For SyncE: `/state/protocols/synce/`

NOTE:

1. Only gNMI is supported.
2. For periodic streaming, the minimum interval is 2 seconds and the maximum interval is 65,535 seconds.
3. UDP streaming telemetry isn't supported.

Configure Timing Data Export

To configure export of timing data, run the following extension service commands on the device:

1. `set system services extension-service request-response grpc ssl local-certificate` *`certificate-id`*
2. `set system services extension-service request-response grpc ssl port 32767`
3. `set system services extension-service notification allow-clients address 0.0.0.0/0`
4. Disable zero suppression by running the command `set services analytics zero-suppression no-zero-suppression`.

Platform-Specific Export Timing Data to Collectors Behavior

Use Feature Explorer to confirm platform and release support for specific features.

Use the following table to review platform-specific behaviors:

Table 19: Export Timing Data to Collectors

Platform	Difference

PTX10016	• PTX10016 supports only SyncE. PTP is not supported on PTX10016.
	• The following leaves are not supported on PTX:
	  • `/ptp/instances/instance[instance-index]/ports/port[index]/unicast-negotiation-port-ds/enable`
	  • `/ptp/instances/instance[instance-index]/globalinfo-ds/e2e-transparent-clock-ds/clock-state`

Interface Express Sensor

Junos Telemetry supports the interface express sensor to export interface operational `UP` and `DOWN` status at a user-configurable rate. This sensor leverages statistics from the physical interface sensor, providing faster and more frequent operational status statistics. The sensor collects and reports only the physical interface operational status from the Flexible PIC Concentrator (FPC). The sensor does not report statistics from the Routing Engine interface.

You can use the sensor to export statistics either over UDP or gRPC services.

For either export method, include the following resource path:

- **/junos/system/linecard/intf-exp/**

Junos OS Release 18.1R1 supports interface express sensor for PTX1000, PTX3000, PTX5000, and PTX10000 routers.

Junos OS Release 19.3R1 supports interface express sensor for MX960, MX2010, and MX2020 routers.

For more information about resource paths, see "Explore Sensor Paths" on page 9.

Junos Telemetry Broadband Edge Statistics Support for Junos Fusion on MX Series

Junos OS Release 19.2R1 enables subscriber-based telemetry streaming if you configure an MX Series device for the Broadband Network Gateway (BNG) with Junos Fusion. Subscribers connect through Junos Fusion Satellite devices. You can use remote procedure calls (gRPC) to export broadband edge (BBE) telemetry statistics to external collectors.

You can stream all BBE resource paths except for the following:

- **/junos/system/subscriber-management/access-network/ancp**
- **/junos/system/subscriber-management/client-protocols/l2tp**
- **/junos/system/subscriber-management/infra/network/l2tp/**

To stream BBE statistics, include a resource path starting with **/junos/system/subscriber-management/** in your gRPC subscription.

To provision the sensor to export data through gRPC, use the `telemetrySubscribe` RPC to specify telemetry parameters.

End-of-Message Notification for Routing Engine Sensor

Junos OS Release 21.2R1 introduces an end-of-message (EoM) Boolean flag for all Junos Telemetry Routing Engine sensors. The flag notifies the collector that the current wrap has completed for a particular sensor path. A wrap is a complete key-value data dump for all the leaves under a sensor path.

The EoM flag also enables the collector to detect when the end of wrap occurs without comparing stream creation timestamp values. The collector receives these values from packets. Comparing these values is time-consuming and delays data aggregation.

To use this feature with gRPC Network Management Interface (gNMI) transport or Remote Procedure Call (gRPC), retrieve the protobuf files from the relevant branch on the Juniper Networks download site:

- GnmiJuniperTelemetryHeaderExtension.proto (gNMI)
- agent.proto (for gRPC)

For example: https://github.com/Juniper/telemetry/blob/master/20.3/20.3R1/protos/GnmiJuniperTelemetryHeaderExtension.proto.

After you download and install the new protobuf files on a collector, the EoM field is present in the packets received.

Physical Ethernet Interface Sensor

Junos OS Release 19.4R1 supports streaming of physical ethernet interface statistics over gRPC or gNMI services on MX960, MX2020, PTX1000, and PTX5000 routers. Both ON_CHANGE and continous streaming are supported.

OpenConfig model **openconfig-if-ethernet.yang** (physical interface level) version 2.6.2 (no configuration) supports this feature.

Use the base resource path **/interfaces/interface/ethernet/state/** over a gRPC or gNMI subscription to export statistics from the Juniper device to an outside collector.

VLAN Sensors

Junos OS Release 19.4R1 supports streaming VLAN statistics for ON_CHANGE using Junos Telemetry and gRPC services on EX4650 and QFX5120 switches.

This feature supports OpenConfig model openconfig-vlan.yang configuration version 1.0.2.

Use the base resource path **/vlans/** in a gRPC subscription to export statistics from the Juniper device to an outside collector.

Other end points you can use in a subscription include:

- **/vlans/vlan/state/name**
- **/vlans/vlan/state/vlan-id**
- **/vlans/vlan/members/**
- **/vlans/vlan/members/member/interface-ref/state/interface/**

- **/vlans/vlan/members/member/interface-ref/state/interface/switched-vlan/state/interface-mode**
- **/vlans/vlan/members/member/interface-ref/state/interface/switched-vlan/state/native-vlan**
- **/vlans/vlan/members/member/interface-ref/state/interface/switched-vlan/state/access-vlan**
- **/vlans/vlan/members/member/interface-ref/state/interface/switched-vlan/state/trunk-vlan**
- **/vlans/vlan/members/member/interface-ref/state/interface/vlan/state/vlan-id**

Transceiver Diagnostics

Junos OS Release 19.4R1 supports streaming of transceiver diagnostic sensors statistics over gRPC or gNMI on MX960, MX2010, MX2020, PTX1000, PTX5000, and the PTX10000 line of routers. Both ON_CHANGE and streaming are supported. Use transceiver diagnostics to help troubleshoot problems, enable network-related decisions, and adjust resources as needed.

This feature supports OpenConfig transceiver model **openconfig-platform-transceiver.yang 0.5.0**.

Use the base resource path **/components/component/transceiver/** in a gRPC or gNMI subscription to export statistics from the Juniper device to an outside collector.

Fields that change continuously, such as temperature, laser bias currant, input power, and output power are not supported for ON_CHANGE.

Support For LSP Statistics

You can provision the LSP statistics sensor **/junos/services/label-switched-path/usage/** to monitor per-MPLS LSP statistics. Telemetry data is streamed from Junos devices and exported through Junos Telemetry system to the external collectors at configurable intervals through gRPC (without involving polling).

Initial support of this feature in Junos OS Release 15.1F6 supported ingress LSPs only when users subscribed to the **/junos/services/label-switched-path/usage/** resource path. Bypass support was added to this feature in Junos OS Release 17.4R1, both ingress and bypass LSP statistics were streamed to the collector.

Statistics that are streamed are similar to the output displayed by the operational mode commands `show mpls lsp bypass statistics` and `show mpls lsp ingress statistics`.

For bypass LSPs, the following information is exported:

- Bypass LSP originating at the ingress router of the protected LSP.
- Bypass LSP originating at the transit router of the protected LSP.
- Bypass LSP protecting the transit LSP as well as the locally originated LSP.

The device exports traffic on both the bypass LSP and the ingress (protected) LSP if the bypass LSP is active.

Use the `telemetrySubscribe` RPC to specify telemetry parameters and provision a sensor to export data through gRPC. Streaming telemetry data through gRPC also requires the OpenConfig for Junos OS module.

See Configuring a Junos Telemetry Interface Sensor (CLI Procedure) for information about configuring a UDP (native) sensor.

See Table 20 on page 216 for the level of LSP sensor support by platform.

Table 20: LSP Support by Platform

Platform	Ingress LSP, UDP Feature Introduced	Ingress LSP, gRPC Streaming Feature Introduced	Bypass LSP Feature Introduced
ACX6360	NA	NA	Junos 19.2R1 RSVP bypass LSP originating at transit node
MX80/MX104	Junos OS Release 15.1F6 Junos OS Release 16.1R3 Junos OS Release 17.2R1	NA	Junos OS Release 17.4R1 Junos OS Release 17.2X75D50+
MX Series with MPC	Junos OS Release 15.1F6	Junos OS Release 16.1R4 Junos OS Release 17.2R1	Junos OS Release 17.4R1 Junos OS Release 17.2X75D50+
PTX5000 with FPC3	NA	Junos OS Release 18.2R1	Junos OS Release 17.4R1

Table 20: LSP Support by Platform *(Continued)*

Platform	Ingress LSP, UDP Feature Introduced	Ingress LSP, gRPC Streaming Feature Introduced	Bypass LSP Feature Introduced
PTX3000 with FPC3	Junos OS Release 15.1F6 Junos OS Release 16.1R3 Junos OS Release 17.2R1	Junos OS Release 16.1R4 Junos OS Release 17.2R1 Junos OS Release 18.2R1	Junos OS Release 17.4R1 Junos OS Release 17.2X75D50+
PTX Series with FPC1/2	Junos OS Release 15.1F6 Junos OS Release 16.1R3 Junos OS Release 17.2R1	Junos OS Release 16.1R4 Junos OS Release 17.2R1 Junos OS Release 18.2R1	Junos OS Release 17.4R1 Junos OS Release 17.2X75D50+
PTX1000	Junos OS Release 16.1R3	Junos OS Release 16.1R4 Junos OS Release 17.2R1	Junos OS Release 17.4R1 Junos OS Release 17.2X75D50+
PTX10000	Junos OS Release 17.3R1	Junos OS Release 17.3R1	Junos OS Release 17.4R1 Junos OS Release 17.2X75D50+
PTX10001-20C	NA	NA	Junos OS Release 19.1R1 RSVP bypass LSP originating at transit node
PTX10002	Junos OS Release 19.1R1	Junos OS Release 19.1R1	NA
VMX	Junos OS Release 17.3R1	Junos OS Release 17.3R1	Junos OS Release 17.4R1 Junos OS Release 17.2X75D50+
MX150	Junos OS Release 17.4R1	Junos OS Release 17.4R1	NA

Table 20: LSP Support by Platform *(Continued)*

Platform	Ingress LSP, UDP Feature Introduced	Ingress LSP, gRPC Streaming Feature Introduced	Bypass LSP Feature Introduced
EX4600	Junos OS Release 18.4R1	NA	NA
EX4650	Junos OS Release 18.3R1	Junos OS Release 18.3R1	NA
EX9200	Junos OS Release 17.3R1	NA	NA
QFX10000	NA	NA	NA
QFX5200	Junos OS Release 17.2R1	Junos OS Release 17.2R1	NA
QFX10002	Junos OS Release 19.1R1	Junos OS Release 19.1R1	NA
QFX5100	Junos OS Release 18.2R1	Junos OS Release 18.2R1	NA
QFX5110	Junos OS Release 18.2R1	Junos OS Release 18.2R1	NA
QFX5120-48Y	Junos OS Release 18.3R1	Junos OS Release 18.3R1	NA
QFX5200	Junos OS Release 18.2R1	Junos OS Release 18.2R1	NA

NPU Sensors

IN THIS SECTION

NPU and Firewall Resource Utilization

IN THIS SECTION

NPU and resource utilization sensors provide visibility into the internal operations of Juniper devices and the state of resource consumption on each device. You can use this information to improve network design and to optimize traffic engineering. Network administrators can use this information for early detection of issues in individual devices, in the overall network and the network traffic.

NOTE: The Juniper Networks Junos YANG Data Model Explorer provides a complete list of sensors and resource paths supported by each platform. It enables you to explore or compare various OpenConfig and Native data model attributes. Use the filter option based on the software release number or product to view the list of resource paths and sensors on each platform.

NPU Utilization for PTX10000 and QFX1000 Series

Table 21: NPU Utilization Sensor (resource path /junos/system/linecard/npu/utilization/)

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
NPU Utilization	NPU Utilization	32-bit	1-100	Number on a scale of 0-100 that indicates the busyness of an NPU.
Memory load • Name	Memory load • Name	—	—	Load on a memory subsystem of the NPU

Table 21: NPU Utilization Sensor (resource path /junos/system/linecard/npu/utilization/) ***(Continued)***

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Memory load	Memory load	—	—	Load on a memory subsystem of the NPU
Memory load • Name	Memory load • Name	string	—	A name string to identify the particular memory subsystems (such as hmc)
Memory load • Average_util • Highest_util • Lowest_util	Memory load • Average_util • Highest_util • Lowest_util	32-bit	—	Various memory utilization metrics
Memory load • Average_cache_hit_rate • Highest_cache_hit_rate • Lowest_cache_hit_rate	Memory load • Average_cache_hit_rate • Highest_cache_hit_rate • Lowest_cache_hit_rate	—	—	Each memory is front ended by a cache. The metrics indicate how these caches are working
Packet Load	Packet Load	—	—	Offered packet load on an internal subsystem of the NPU, like the following: • loopback_pps • recirculation_pps • wan_and_host_inject_pps • asic_to_host_pps

Table 21: NPU Utilization Sensor (resource path /junos/system/linecard/npu/utilization/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Packet Load: • Identifier	Packet Load: • Identifier	string	—	Each internal subsystem of the NPU has a name
Packet Load: • rate	Packet Load: • rate	64-bit	—	Rate of packets received
Packet Load: • average_instructions_per_packet • average_wait_cycles_per_packet • average_cycles_per_packet	Packet Load: • average_instructions_per_packet • average_wait_cycles_per_packet • average_cycles_per_packet	32-bit	—	Indicates the compute load on the NPU. These metrics are not valid for the PF chip on the PTX10000 routers or QFX10000 switches.

Table 22: NPU Memory Sensor for PTX10000 and QFX1000 Series (resource path /junos/system/linecard/npu/memory/)

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Memory Summary	Memory Summary	-	-	NPU memory utilization summary per memory type
Memory Summary • Resource_name	Memory Summary • Resource_name	-	string	A name string to identify the particular memory blocks such as KHT (cuckoo hash tables), edf, flt, sfm, fcv. Beta-0, beta-1, policer, and pclt

Table 22: NPU Memory Sensor for PTX10000 and QFX1000 Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Memory Summary: • size	Memory Summary: • size	64-bit	%	Size memory utilization metrics
Memory Summary: • allocated	Memory Summary: • allocated	64-bit	%	Allocated memory utilization metrics
Memory Summary: • utilization	Memory Summary: • utilization	32-bit	%	Memory utilization metrics
Application memory partition summary		-	-	Detailed statistics for NPU memory partitions per application; examples include plctfilter, plct-ingr-nh, plctegr-nh, plct-rt, and plctmisc.
Application memory partition summary: • Application_name	Application memory partition summary: • Application_name	string	-	Name of the application for which NPU memory is allocated.
Application memory partition summary: • Bytes_allocated • Allocation_count • Free_count	Application memory partition summary: • Bytes_allocated • Allocation_count • Free_count	32-bit	-	Various memory values for allocation and free count.

NPU Utilization for PTX Series

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/)

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
NPU Memory • L2 domain	Exported property names: • mem-util-kht-l2domain-allocated • mem-util-kht-l2domain-size • mem-util-kht-l2domain-utilization	—	32768 (size in your table)	An equivalent of a logical interface index. Logical interfaces is a contributor.
NPU Memory • SLU MY-MAC	Exported property names: • mem-util-kht-slu-my-mac-size • mem-util-kht-slu-my-mac-allocated • mem-util-kht-slu-my-mac-utilization	entry	3072	Used for both VRRP MAC and MYMAC indentification. Populated during FPC intitialization
NPU Memory • Forwarding table: edb0	Exported property names: • mem-util-kht-dlu-edb0-allocated • mem-util-kht-dlu-edb0-size • mem-util-kht-dlu-edb0-utilization	entry	16777216	Used by L3 / L2 forwarding table entries, including IPv4, IPv6, MPLS. Only route entries are located in this database. Entries size vary and depends on the entry type.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
NPU Memory • Forwarding table: edb1	Exported property names: • mem-util-kht-dlu-edb1-allocated • mem-util-kht-dlu-edb1-size • mem-util-kht-dlu-edb1-utilization	entry	4194304	Used by flow table. Populated only when IPFIX is enabled.
Firewall / Filter • Filter instances	Exported property names: not available	entry	8192	Reflects the number of filter instances (and not the number of configured filters) Regular filters, interface-specific filter creates a new instance, there is no program sharing
Firewall / Filter • Filter terms	Exported property names: • mem-util-flt-action-entries-utilization • mem-util-flt-action-entries-allocated • mem-util-flt-action-entries-size	—	65536	Reflects the number of filter terms. Regular filters, interface-specific filter creates a new instance. There is no program sharing
Firewall / Filter • Filter alpha block [0]	Exported property names: • mem-util-kht-flt0-size • mem-util-kht-flt0-allocated • mem-util-kht-flt0-utilization	—	131072	Used for longest prefix matches (source, destination addresses). Contributors are source or destination prefix lists. IPv6 prefixes with matches longer than /64 occupy two entries.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Firewall / Filter • Filter alpha block [1]	Exported property names: • mem-util-kht-flt1-size • mem-util-kht-flt1-allocated • mem-util-kht-flt1-utilization • mem-util-flt-alpha-1-kht-size • mem-util-flt-alpha-1-kht-allocated • mem-util-flt-alpha-1-kht-utilization • mem-util-flt-alpha-1-bft-0-size • mem-util-flt-alpha-1-bft-0-allocated • mem-util-flt-alpha-1-plt-size • mem-util-flt-alpha-1-plt-allocated • mem-util-flt-alpha-1-plt-utilization	—	131072	Used for longest prefix matches (source, destination addresses). Contributors are source or destination prefix lists.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Firewall / Filter • Filter beta block [0]	Exported property names: • mem-util-beta-0-bank-0-size • mem-util-beta-0-bank-0-allocated • mem-util-beta-0-bank-0-utilization • mem-util-beta-0-bank-1-size • mem-util-beta-0-bank-1-allocated • mem-util-beta-0-bank-1-utilization • mem-util-beta-0-bank-2-size • mem-util-beta-0-bank-2-allocated • mem-util-beta-0-bank-2-utilization • mem-util-beta-0-bank-3-size • mem-util-beta-0-bank-3-allocated • mem-util-beta-0-bank-3-utilization • mem-util-beta-0-bank-4-size	—	65536	Used for range matches (source and destination ports). Contributors are ports, port ranges, and other match conditions. This is a tree structure. Each match condition may translate into 1 or more entries, depending on the number of ranges.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) ***(Continued)***

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
	• mem-util-beta-0-bank-4-allocated • mem-util-beta-0-bank-4-utilization			

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Firewall / Filter • Filter beta block [1]	Exported property names: • mem-util-beta-1-bank-0-size • mem-util-beta-1-bank-0-allocated • mem-util-beta-1-bank-0-utilization • mem-util-beta-1-bank-1-size • mem-util-beta-1-bank-1-allocated • mem-util-beta-1-bank-1-utilization • mem-util-beta-1-bank-2-size • mem-util-beta-1-bank-2-allocated • mem-util-beta-1-bank-2-utilization • mem-util-beta-1-bank-3-size • mem-util-beta-1-bank-3-allocated • mem-util-beta-1-bank-3-utilization • mem-util-beta-1-bank-4-size	—	65536	Used for range matches (source and destination ports). Contributors are ports, port ranges, and other match conditions. This is a tree structure. Each match condition may translate into 1 or more entries, depending on the number of ranges.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
	• mem-util-beta-1-bank-4-allocated • mem-util-beta-1-bank-4-utilization • mem-util-flt-beta-1-bank-5-size • mem-util-flt-beta-1-bank-5-allocated • mem-util-flt-beta-1-bank-5-utilization			
Firewall / Filter • Secondary Facet Match	Exported property names: • mem-util-sfm-entries-size • mem-util-sfm-entries-allocated • mem-util-sfm-entries-utilization	—	8192	Used by other match conditions, such as tcp-flags.
Firewall / Filter • Special Cover Vector	Exported property names: • mem-util-flt-scv-size • mem-util-flt-scv-allocated • mem-util-flt-scv-utilization	—	131072	An auxiliary data structure used to optimize for direction indifference matches (source or destination addresses ports), excepts and ranges (plus wildcards). Contributors are filters with irregular patterns (direction indifference matches, excepts, ranges, wildcards) will contribute to the utilization.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) ***(Continued)***

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Firewall / Filter • FCV block [1]	Exported property names: • mem-util-fcv-blk-1-size • mem-util-fcv-blk-1-allocated • mem-util-fcv-blk-1-utilization	B	65536	Cover vector FCV block 1.
Firewall / Filter • FCV block [2]	Exported property names: • mem-util-fcv-blk-2-size • mem-util-fcv-blk-21allocated • mem-util-fcv-blk-2-utilization	B	65536	Cover vector FCV block 2.
Firewall / Filter • FCV block [3]	Exported property names: • mem-util-fcv-blk-3-size • mem-util-fcv-blk-3-allocated • mem-util-fcv-blk-3-utilization	B	65536	Special cover vector FCV block 3.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
NPU Memory • Forwarding table: edb0	Exported property names: • mem-util-kht-dlu-edb0-allocated • mem-util-kht-dlu-edb0-size • mem-util-kht-dlu-edb0-utilization	entry	16777216	Used by L3 / L2 forwarding table entries, including IPv4, IPv6, MPLS. Only route entries are located in this database. Entries size vary and depends on the entry type.
NPU Memory • Forwarding table: edb1	Exported property names: • mem-util-kht-dlu-edb1-allocated • mem-util-kht-dlu-edb1-size • mem-util-kht-dlu-edb1-utilization	entry	4194304	Used by flow table. Populated only when IPFIX is enabled.
NPU Memory • Forwarding table: edb0	Exported property names: • mem-util-kht-dlu-edb0-allocated • mem-util-kht-dlu-edb0-size • mem-util-kht-dlu-edb0-utilization	entry	16777216	Used by L3 / L2 forwarding table entries, including IPv4, IPv6, MPLS. Only route entries are located in this database. Entries size vary and depends on the entry type.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) ***(Continued)***

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
NPU Memory • Forwarding table: edb1	Exported property names: • mem-util-kht-dlu-edb1-allocated • mem-util-kht-dlu-edb1-size • mem-util-kht-dlu-edb1-utilization	entry	4194304	Used by flow table. Populated only when IPFIX is enabled.
Firewall / Filter • Policer IDs	Exported property names: • mem-util-policer-id-size • mem-util-policer-id-allocated • mem-util-policer-id-utilization	B	16384	Contributors are firewall policers, and interface policers

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Firewall / Filter • Policer/Counter space	Exported property names: • mem-util-plct-size • mem-util-plct-allocated • mem-util-plct-utilization • mem-util-plct-filter-bytes-allocated • mem-util-plct-filter-allocation-count • mem-util-plct-filter-free-count • mem-util-plct-ing-nh-bytes-allocated • mem-util-plct-ing-nh-allocation-count • mem-util-plct-ing-nh-free-count • mem-util-plct-egr-nh-bytes-allocated • mem-util-plct-egr-nh-allocation-count • mem-util-plct-egr-nh-free-count • mem-util-plct-misc-bytes-allocated • mem-util-plct-misc-allocation-count	B	131072	Issues 1 word per counter, 3 words per single rate policer, and 5 words for tricolor policers.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
	• mem-util-plct-misc-free-count • mem-util-plct-memory-size • mem-util-plct-memory-allocated • mem-util-plct-memory-utilization			
Next-hops and encapsulation • IRP Memory: Load-balancing partition	Exported property names: • mem-util-jnh-loadbal-allocated • mem-util-jnh-loadbal-size • mem-util-jnh-loadbal-utilization	KWords	128	Load-balancing data structures. Contributors are aggregated Ethernet and multipath.
Next-hops and encapsulation • IRP Memory: Next-hop partition	Exported property names: • mem-util-jnh-loadbal-allocated • mem-util-jnh-loadbal-size • mem-util-jnh-loadbal-utilization • mem-util-jnh-loadbal-utilization	KWords	256	Used for next-hops. Contributors are next-hops.

Table 23: NPU Memory Sensor for PTX Series (resource path /junos/system/linecard/npu/memory/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
Next-hops and encapsulation • IRP Memory: EDF partition	Exported property names: • mem-util-edf-public-words-allocated • mem-util-edf-public-words-size • mem-util-edf-public-words-utilization	KWord s	320	Encapsulation data structures. Contributors are forwarding next-hops.
Next-hops and encapsulation • IRP Memory: MPLS label memory	Exported property names: • mem-util-jnh-mpls-allocated • mem-util-jnh-mpls-size • mem-util-jnh-mpls-utilization	KWord s	128	MPLS Label structures. Contributors are MPLS Labels.

Table 24: NPU Utilization Sensor for PTX Series (resource path /junos/system/linecard/npu/utilization/)

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
NPU Utilization • Utilization	Exported property names: • util-metric	percent	—	Current PE chip utilization. Contributor is traffic stream.

Table 24: NPU Utilization Sensor for PTX Series (resource path /junos/system/linecard/npu/utilization/) *(Continued)*

Native Sensor Property Name	gRPC Sensor Property Name	Unit Type	Range	Description
NPU Utilization • Packet Load	Exported property names: • util-loopback-pps-rate • util-recirculation-pps-rate • util-asic-to-host-pps-rate • util-wan-and-host-inject-pps-rate	pps	—	Traffic load on the chip which includes loopback, recirculated, WAN, and host-injected and ASIC-to-host traffic. Contributors are traffic stream pps.
NPU Utilization • Memory Load	Exported property names: • util-hmc-average-util • util-hmc-highest-util • util-hmc-lowest-util • util-hmc-average-cache-hit-rate • util-hmc-highest-cache-hit-rate • util-hmc-lowest-cache-hit-rate	percent/per-sec	—	HMC memory utilization and memory cache hit rate

Firewall Resource Utilization

You can export statistics on firewall resource utilization by subscribing to the OpenConfig resource path `/components/component/integrated-circuit/pipeline-counters/`. The operational state sensors display the total supported filter entries and used entries in terms of count and bytes.

State sensors for firewall resource utilization are:

- `/components/component/integrated-circuit/pipeline-counters/packet/lookup-block/state/acl-memory-used-entries`
- `/components/component/integrated-circuit/pipeline-counters/packet/lookup-block/state/acl-memory-total-entries`
- `/components/component/integrated-circuit/pipeline-counters/packet/lookup-block/state/acl-memory-used-bytes`
- `/components/component/integrated-circuit/pipeline-counters/packet/lookup-block/state/acl-memory-total-bytes`

The values of the sensors use the following calculations:

- acl-memory-used-entries = round (UtilizationOfTables [a number from 0 to 100] / 100 * 64000)
  The value of UtilizationOfTables is the maximum value of the following NPU memory statistics, which are leaves under the native sensor `/junos/system/linecard/npu/memory/`:
  - `mem-util-flt-vfilter-utilization`
  - `mem-util-flt-phyfilter-utilization`
  - `mem-util-flt-action-entries-utilization`
  - `mem-util-fcv-blk-1-utilization`
  - `mem-util-fcv-blk-2-utilization`
  - `mem-util-fcv-blk-3-utilization`
  - `mem-util-flt-scv-utilization`
  - `mem-util-beta-0-bank-0-utilization`
  - `mem-util-beta-0-bank-1-utilization`
  - `mem-util-beta-0-bank-2-utilization`
  - `mem-util-beta-0-bank-3-utilization`
  - `mem-util-beta-0-bank-4-utilization`
  - `mem-util-beta-1-bank-1-utilization`
  - `mem-util-beta-1-bank-2-utilization`

    - mem-util-beta-1-bank-3-utilization
    - mem-util-beta-1-bank-4-utilization
    - mem-util-beta-1-bank-5-utilization
    - mem-util-flt-alpha-1-kht-utilization
    - mem-util-flt-alpha-1-plt-utilization
    - mem-util-policer-id-utilization
    - mem-util-plct-utilization
- acl-memory-total-entries = 64K
- acl-memory-used-bytes = acl-memory-used-entries * 8
- acl-memory-total-bytes = acl-memory-total-entries * 8 = 64k *8

Telemetry Streaming Support for ZR/ZR+ Optics on MPC 10 Linecards

Starting in Junos OS Release 24.4R1, telemetry data streaming for ZR and ZR+ optics is implemented on the MPC 10 line cards. The following resource paths are supported:

```
/components/component/transceiver/config/fec-mode - 'config'

/components/component/transceiver/state/fec-mode - 'leaf'
/components/component/transceiver/state/fec-status - leaf
/components/component/transceiver/state/module-functional-type - 'leaf'
/components/component/transceiver/state/fault-condition - leaf
/components/component/transceiver/state/fec-uncorrectable-blocks - leaf
/components/component/transceiver/state/fec-corrected-bits - leaf
/components/component/transceiver/physical-channels/channel/state/output-frequency - 'leaf'
/components/component/transceiver/physical-channels/channel/state/associated-optical-channel -
'leaf'
/components/component/optical-channel/state/frequency - 'leaf'
/components/component/optical-channel/state/line-port - 'leaf'

/components/component/optical-channel/state/output-power/ - instant/avg/min/max/interval/min-
```

```
time/max-time - 'container'
/components/component/optical-channel/state/input-power/ - instant/avg/min/max/interval/min-time/
max-time - 'container'
/components/component/optical-channel/state/laser-bias-current/ - instant/avg/min/max/interval/
min-time/max-time - 'container'
/components/component/optical-channel/state/chromatic-dispersion/ - instant/avg/min/max/interval/
min-time/max-time - 'container'
/components/component/optical-channel/state/second-order-polarization-mode-dispersion/ -
instant/avg/min/max/interval/min-time/max-time - 'container'
/components/component/optical-channel/state/polarization-dependent-loss/ - instant/avg/min/max/
interval/min-time/max-time - 'container'
/components/component/optical-channel/state/osnr/ - instant/avg/min/max/interval/min-time/max-
time - 'container'
/components/component/optical-channel/state/esnr/ - instant/avg/min/max/interval/min-time/max-
time - 'container'
/components/component/optical-channel/state/carrier-frequency-offset/ - instant/avg/min/max/
interval/min-time/max-time  - 'container'
/components/component/optical-channel/state/pre-fec-ber/ - instant/avg/min/max/interval/min-time/
max-time - 'container'
/components/component/optical-channel/state/modulator-bias-xi/ - instant/avg/min/max/interval/
min-time/max-time - 'container'
/components/component/optical-channel/state/modulator-bias-xq/ - instant/avg/min/max/interval/
min-time/max-time - 'container'
/components/component/optical-channel/state/modulator-bias-yi/ - instant/avg/min/max/interval/
min-time/max-time - 'container'
/components/component/optical-channel/state/modulator-bias-yq/ - instant/avg/min/max/interval/
min-time/max-time - 'container'
/components/component/optical-channel/state/modulator-bias-x-phase/ - instant/avg/min/max/
interval/min-time/max-time - 'container'
/components/component/optical-channel/state/modulator-bias-y-phase/ - instant/avg/min/max/
interval/min-time/max-time - 'container'
/components/component/optical-channel/state/sop-roc/ - instant/avg/min/max/interval/min-time/max-
time - 'container'
```

6

PART

Best Practices for Implementing Junos Telemetry

Telemetry Resources

Use the following resources to deploy and manage the Junos Telemetry solution in a network. GitHub is a code-hosting platform for version control and collaboration. Juniper Networks is part of the OpenConfig community, which uses GitHub to develop telemetry code and store documentation. In addition to GitHub resources, Juniper provides sensor explorer tools.

Table 25: Telemetry Resources

Telemetry Resources	Description
YANG models	Starting in Junos OS Evolved Release 23.4R1, all YANG data models for a given OS and release are in a single download package and GitHub repository. The package and repository include the native configuration, state, and RPC data models and the OpenConfig and Internet Engineering Task Force (IETF) data models supported by that OS.
Junos Telemetry Sensor Explorer	From releases 20.2R1 up to 23.1R1, the sensor information is available in the Telemetry Sensor Explorer.
"Legacy Sensor Paths" on page 260	Telemetry sensors and specific information about some legacy sensors.
Juniper telemetry on GitHub	Juniper telemetry models, augments, and deviations.
Protobuf file	Juniper protocol buffer files, organized by Junos OS Release.
gNMI protobuf file	Juniper gNMI protocol buffer files, organized by Junos OS Release.

Guidelines for Specifying Data Reporting Intervals Junos Telemetry

IN THIS SECTION

The Junos Telemetry enables you to provision sensors to collect and export data for various system resources without involving polling. A management station sends one request to stream periodic updates.

You can configure telemetry sensors to report data at a specified interval either through the command line interface (CLI) or through the OpenConfig for Junos `telemetrySubscribe` remote procedure call (RPC). To configure using the CLI, include the `reporting-rate` *`seconds`* statement at the `[edit services analytics export-profile` *`profile-name`*`]` hierarchy level. For the `telemetrySubscribe` RPC, specify the sampling interval parameter, in milliseconds. In both cases, the interval specifies the amount of time between each subsequent export of data.

Determine the Reporting Interval for a System Resource

To determine the appropriate reporting interval for a specific system resource, follow these guidelines:

- Identify the required export interval for a given object, such as an interface.
- Identify the maximum number of objects reported by the sensor, such as the number of physical interfaces configured on a line card.
- Identify the minimum number of objects reported on each interval for a given sensor.
- Use the following formula to determine the best reporting interval:
  - Reporting interval = Required Export Interval Per Object * Minimum Number of objects reported on each Interval / Maximum Number of Objects.

For example, a business requirement specifies reporting interface statistics every 30 seconds. At every interval, the system reports 10 interface records, and each line card has 96 interfaces. By applying the reporting-interval formula, you derive a 3.125-second reporting interval. Currently, the reporting interval can't be configured to anything but multiples of 2 seconds. Therefore, for this example, configure the reporting interval as 2 seconds in the CLI or 2000 milliseconds in the OpenConfig RPC.

> **TIP**: The same metric might be reported more than once over a 30-second interval. For effective visualization and data manipulation, it is common to aggregate data over fixed time spans.

RELATED DOCUMENTATION

Understanding Junos Telemetry | 2

Guidelines for Aggregating Junos Telemetry Data

IN THIS SECTION

One important feature of the Junos Telemetry is that data processing occurs at the collector that streams data, rather than the device. Data is not automatically aggregated, but it can be aggregated for analysis.

Data aggregation is useful in the following scenarios:

- Data for the same metric over fixed spans of time, such as, the average number of physical interface ingress errors over a 30-second interval.
- Data from different sources (such as multiple line cards) for the same metric, such as label-switched path (LSP) statistics or filter counter statistics.
- Data from multiple sources, such as input and output statistics for aggregated Ethernet interfaces.

The following sections describe how to perform data aggregation for various scenarios. The examples in these sections use the InfluxDB time-series database to accept queries on telemetry data. InfluxDB is an open source database written in the Go programming language that is designed specifically to handle time-series data.

Aggregating Data Over Fixed Time Span

Aggregating data for the same metric over a fixed time span is a common and useful way to detect trends. Metrics can include gauges, that is, single values, or cumulative counters. You might also want to aggregate data continuously.

- "Example: Aggregating Data for Gauge Metrics" on page 244
- "Example: Aggregating Data for Cumulative Statistics" on page 245

Example: Aggregating Data for Gauge Metrics

In this example, data for `JuniperNetworksSensors.jnpr_interface_ext.interface_stats.egress_queue_info.current_buffer_occupancy` from `port.proto` is written to the InfluxDB database with tags that identify the host name, an interface name and corresponding queue number and measurement called `current_buffer_occupancy` . See Table 26 on page 244 for the specific values used in this example.

Table 26: Telemetry Data Values

Time Stamp (seconds)	Value	Tags
1458704133	1547	queue_number=0,interface_name=‘xe-1/0/0’,host=‘sjc-a’
1458704143	3221	queue_number=0,interface_name=‘xe-1/0/0’,host=‘sjc-a’
1458704155	4860	queue_number=0,interface_name=‘xe-1/0/0’,host=‘sjc-a’
1458704166	6550	queue_number=0,interface_name=’xe-1/0/0’,host=’sjc-a’

Each measurement data point has a timestamp and recorded value. In this example, the tag `queue_number` is the numerical identifier of the interface queue.

To aggregate this data over 30-second intervals, use the following influxDB query:

```
select mean(value) from current_buffer_occupancy
         where  time >= $time_start and time <= $time_end and
                          queue_number='0' and interface_name='xe-1/0/0' and host='sjc-a'
                  group by time(30s)
```

For `$time_start` and `$time_end`, specify the actual range of time.

Example: Aggregating Data for Cumulative Statistics

Some Junos telemetry interface sensors report cumulative counter values, such as the number of ingress packets, defined as `JuniperNetworksSensors.jnpr_interface_ext.interface_stats.ingress_stats.packets`.

It is common to derive traffic rates from packet or byte counters. Unlike with gauge metrics, the initial data point in the series for cumulative counters is used only to set the baseline.

Use the following guidelines to create a database query for cumulative statistics:

- Calculate the cumulative value for a specific time interval. You can calculate either an average among several data points recorded during the time interval, or you can interpolate a value. All data points should belong to the same series. If a counter reset has occurred between the two data points reported at different times, do not use both data points.
- Determine the appropriate value for the previous time interval. If a counter is reset since the last update, declare that value as unavailable.
- If the previous interval is available, calculate the difference between the data points and the traffic rate.

These guidelines are summarized in the following influxDB query. This query assumes that data is stored in the measurement `ingress_packets`. The query uses the same tags as the gauge metric example as well as the tag for counter initialization time, `init_time`. The query uses average values over a 30-second time interval. It calculates the rate for the metrics that have the same counter initialization.

```
select non_negative_derivative(mean(value)) from ingress_packets
        where  time >= $time_start and time <= $time_end and
               interface_name='xe-1/0/0' and host='sjc-a'
        group by time(30s), init_time
```

Use the following query to calculate the number of packets received over an interval of time, without deriving the rate.

```
select difference(mean(value)) from ingress_packets
          where  time >= $time_start and time <= $time_end and
                 interface_name='xe-1/0/0' and host='sjc-a'
          group by time(30s), init_time
```

In some cases, more than one aggregated data point is returned by the query for a particular time interval. For example, four data points are available for a time interval. Two data points have `init_time t0`, and the other two have `init_time t1`. You can run a query that uses the last change timestamp tag, `last_change`, instead of `init_time`, to calculate the difference and to derive the rate between the two data points with the same last change timestamp.

```
select difference(mean(value)) from ingress_packets
                 where  time >= $time_start and time <= $time_end and
                           interface_name='xe-1/0/0' and host='sjc-a'
      group by time(30s), last_change
```

TIP: These queries can all be run as continuous queries and can periodically populate new time-series measurements.

Aggregating Data From Multiple Sources

Certain metrics are reported from multiple line cards or packet forwarding engines. It is useful to aggregate data derived from different sources in the following scenarios:

- Packet and byte counts for label-switched paths (LSPs) are reported separately by each line card. However, a view of LSP paths for the entire device is required for path computation element controllers.
- For Juniper Networks devices that support virtual output queues, the tail drop or random early detection drop statistics for each queue are reported separately by each line card for every physical interface. It is useful to be able to aggregate the statistics for all the line cards for an interface.
- Filter counters for a firewall filter attached to a forwarding table or to an aggregated Ethernet interface are reported separately by each line card. It is useful to aggregate the statistics for all the line cards.

To aggregate data from multiple sources, perform the following:

1. Aggregate data for a specific period of time for each source, for example, each line card.

2. Aggregate the data you derive for each source in *step 1*.

For data stored in an InfluxDB database, you can complete *step 1* in the procedure by running a continuous query and populating a new measurement. We strongly recommend that you group the data points according to each source. For example, for LSP statistics, the `component_id` in the the gpb message identifies the line card sending the data. Group the data points based on each unique `component_id`.

Example: Aggregating Data from Multiple Sources

In this example, you run two queries to derive the LSP packet rate for data from all line cards.

First, you run the following continuous query on the measurement named `lsp_packet_count` for each `component_id` tag and the `counter_name` tag. Each unique `component_id` tag corresponds to a different line card. This query populates a new measurement, `lsp_packet_rate`.

```
select non_negative_derivative(mean(value)) as value from lsp_packet_count
          into lsp_packet_rate
          group by time(30s), component_id, counter_name, host
```

NOTE: The LSP statistics sensor does not report counter initialization time.

Use the new measurement derived from this continuous query—`lsp_packet_count`—to run the following query, which aggregates data from all line cards for packet rates for an LSP named `lsp-sjc-den-1`.

```
select sum(value) from lsp_packet_rate
          where counter_name='lsp-sjc-den-1', host='sjc-a'
```

NOTE: Because this query does not group data according to the `component_id` tag, or line card, the LSP packet rates from all components, or line cards, are returned.

Aggregating Data for Multiple Metrics

It can be useful to aggregate metrics for multiple values. For example, for aggregated Ethernet interfaces, you would typically want to track packet and byte rates for each interface member as well as interface utilization for the aggregated link.

Example: Aggregating Multiple Metric Values

In this example, you run the following two queries:

- Continuous query to derive ingress packet counts for each member link in an aggregated Ethernet interface
- Query to aggregate packet count data for all the member links that belong to the same aggregated Ethernet interface

The following continuous query derives a measurement, `ingress_packets`, for each member link in an aggregated Ethernet interface. The `interface_name` tag identifies each member interface. You also use the `parent-ae-name` tag to identify membership in a specific aggregated Ethernet interface. Grouping each member link with the `parent-ae-name` tag ensures that data is collected only for current member links. For example, an interface might change its membership during the reporting interval. Grouping member interfaces with the specific aggregated Ethernet interface means that data for the member link will not be transferred to the new aggregated Ethernet interface of which it is now a member.

```
select difference(mean(value)) as value from ingress_packets
       into ingress_packets_difference
       group by time(30s), component_id, interface_name, host, parent-ae-name
```

The following query aggregates data for the ingress packets for the aggregated Ethernet interface, that is all member links.

```
select sum(value) from ingress_packets_difference
       where parent-ae-name='ae0' and host='sjc-a'
```

NOTE: This query aggregates data for aggregated Ethernet interface `ae0`. The `parent-ae-name` tag does not verify the actual member links.

RELATED DOCUMENTATION

Understanding Junos Telemetry | 2

Guidelines for Exporting Subscriber Statistics and Queue Statistics for Dynamic Interfaces and Interface-Sets

Use subscriber and queue statistics for dynamic interfaces and interface-sets to support remote analytics and monitoring. Juniper Networks MX Series Universal Routers (MX Series) function as a Broadband Network Gateway (BNG).

Before enabling export of subscriber statistics and queue statistics for dynamic interfaces and interface-sets, consider the following limitations:

- On MX Series devices supporting the Modular Port Concentrator 2 (MPC2), a slow internal refresh cycle for queue statistics can occur. This refresh cycle can be lengthy at full line-card scale. This cycle can be lengthy at full line card scale. If the subscription frequency is higher than the internal refresh cycle, exported data may appear stale across reporting intervals.

- The unified in-service software upgrade (ISSU) feature lets you upgrade devices between two different Junos OS releases with no control-plane disruption and minimal traffic disruption. Dynamic interfaces and interface-sets created before ISSU and before Junos OS Release 18.4R1 don't support telemetry for subscriber and queue statistics.

- The subscription frequency must exceed the time required to export telemetry. If the volume of data can't be exported before the next reporting interval, the export continues to completion, and the next reporting interval immediately starts. In such scenarios, continuous streaming results—behavior that might not be wanted.

- Multiple sensors from the dynamic-interfaces sub-tree can be subscribed to simultaneously. Because a single Junos component supports streaming of these sub-tree sensors, the time to export the sensor data for each subscription might extend.

- Enable export only for active queues. To enable export only for active queues, include the `queues` statement at the `[[edit dynamic-profiles` *profile-name* `telemetryqueue-statistics $junos-interface-name]` or `[[edit dynamic-profiles` *profile-name* `telemetry queue-statistics $junos-interface-set-name]` hierarchy level. This approach reduces the volume of data for each reporting interval.

RELATED DOCUMENTATION

Enabling Export of Subscriber Statistics and Queue Statistics for Dynamic Interfaces and Interface-Sets | **168**

7

PART

Junos Telemetry Plug-ins

CHAPTER 1

Network Telemetry Framework (NTF) Agent

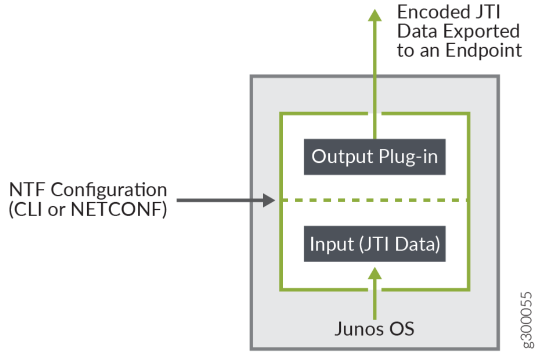
IN THIS CHAPTER

NTF Agent Overview

Junos OS exposes telemetry data over gRPC and UDP as part of the Junos Telemetry infrastructure. To stream telemetry data to your existing telemetry and analytics infrastructure you require an external entity such as the Network Telemetry Framework (NTF) to convert the data into a compatible format. Starting in Junos OS Release 18.4R1, the Network Telemetry Framework agent feature provides an on-box solution that allows you to configure and customize to which endpoint (such as IPFIX and Kafka) the Junos Telemetry data is delivered and in which format (such as AVRO, JSON, and MessagePack) the data is encoded.

The NTF agent uses an output plug-in to translate Junos Telemetry data into a format that is suitable for a particular endpoint. The NTF agent subscribes to Junos Telemetry data with user-defined sensor information. The NTF agent encodes the data in the required format and exports the translated data to the endpoint (see Figure 9 on page 253). You can configure the NTF agent by using Junos OS CLI or NETCONF.

Figure 9: NTF Agent Architecture



RELATED DOCUMENTATION

Configuring NTF Agent | 253

Configuring NTF Agent

To configure a Network Telemetry Framework (NTF) agent instance to send telemetry data to a single endpoint:

1. Create a service agent instance.

```
[edit services analytics agent]
user@host# edit service-agents agent-name
```

2. Configure parameters for the service agent input plug-in. The input plug-in options include `analytics`, `input-ipfix`, and `input-jti-ipfix`. See the *inputs* configuration statement for a description of the syntax.

> **NOTE**: When you modify the input plug-in configuration of a service agent instance, the associated service agent daemon is restarted.

```
[edit services analytics agent service-agents agent-name]
user@host# edit inputs input-plugin-name parameters key-value-pairs
```

3. Configure parameters for the service agent output plug-in. Parameters are based on the key/value pair requirements of the output plug-in. For each service agent instance, you can configure only one endpoint to which to export data. The output plug-in options include `ouput-ipfix`, `kafka`, and `file`. See the *outputs* configuration statement for a description of the syntax.

   NOTE: When you modify the output plug-in configuration of a service agent instance, the associated service agent daemon is restarted.

   ```
   [edit services analytics agent service-agents agent-name]
   user@host# set outputs ouput-plugin-name parameters key-value-pairs
   ```

4. (Optional) For each service agent instance, you can configure more than one input plug-in to push data to the output plug-in. To illustrate, the basic format of the configuration looks like:

   ```
   [edit services analytics agent service-agents agent1]
       inputs {
       input-plugin1 {
           parameters {
               input-plugin1-key-value-pairs;
           }
       }
       input-plugin2 {
           parameters {
               input-plugin2-key-value-pairs;
           }
       }
   }
       outputs {
           output-plugin {
               parameters {
                   output-plugin-key-value-pairs;
               }
           }
       }
   ```

5. (Optional) Delete a service agent instance.

   ```
   user@host# delete services analytics agent service-agents agent-name
   ```

To configure tracing operations for NTF agent:

1. Specify the name of the file to receive the output of the tracing operation. The file is stored in the /var/log/ directory of your device.

```
[edit services analytics agent]
user@host# edit traceoptions filename filename
```

2. Specify the severity level for messages to be logged.

```
[edit services analytics agent]
user@host# edit traceoptions flag {debug | error | info | trace}
```

SHOW COMMANDS and LOG FILES

1. Display the running service agent instances of the NTF agent.

```
user@host> show services analytics agent [brief | detail]
```

2. Additionally, view information about service agent instances, such as whether the input and output plug-ins have been initialized, in the service agent log file: /var/log/*agent-name*.log.

RELATED DOCUMENTATION

Configuring the BNG as an IPFIX Mediator to Collect and Export IPFIX Data

Configuring the Collection and Export of Local Telemetry Data on the IPFIX Mediator

IPFIX Mediation on the BNG

NTF Agent Overview | 252

Telemetry Data Collection on the IPFIX Mediator for Export to an IPFIX Collector

CHAPTER 2

Open Source Plug-ins

IN THIS CHAPTER

Junos Telemetry Plug-ins for Open Source Data Collectors

Well-known open source data collectors, such as Telegraf have a plug-in-based architecture, where Junos Telemetry plug-ins can be written to translate Junos Telemetry data into a format that can be easily understood by the collector. The following table provides links to the public Junos Telemetry plug-in files for transporting Junos Telemetry data over gNMI.

Table 27: Junos Telemetry Plug-ins for Open Source Data Collectors

Open Source Data Collector	Junos Telemetry Plug-ins for OpenConfig key-value Pairs over gNMI
Telegraf	jti_openconfig_telemetry_gnmi

8

PART

Configuration Statements and Operational Commands

Junos CLI Reference Overview

We've consolidated all Junos CLI commands and configuration statements in one place. Read this guide to learn about the syntax and options that make up the statements and commands. Also understand the contexts in which you'll use these CLI elements in your network configurations and operations.

- Junos CLI Reference

Click the links to access Junos OS and Junos OS Evolved configuration statement and command summary topics.

- Configuration Statements
- Operational Commands

9

PART

Legacy Information

Legacy Sensor Paths

IN THIS SECTION

Supported gRPC and gNMI Sensors

Starting with Junos OS Release 20.1R1, the on-device gRPC framework is upgraded to version v1.18.0 and is applied to both JET and Junos Telemetry. This version includes important enhancements for gRPC. Earlier legacy Junos OS platform versions (non-Occam) will continue to use version v1.3.0.

Starting with Junos OS Release 20.2R1, Junos Telemetry supports MX routers with dual Routing Engines or MX Series Virtual Chassis. The telemetry support is available for all Packet Forwarding Engine and Routing Engine sensors currently supported on MX Series routers. The level of sensor support currently available for MX Series routers is based on whether telemetry data is streamed or exported **ON_CHANGE** over UDP, or remote procedure call (gRPC) services, or gRPC Network Management Interface (gNMI) services. Additionally, Junos Telemetry operational mode commands provide details for all Routing Engines and MX Series Virtual Chassis.

Table 28: gRPC Sensors

Resource Path	Description
/interfaces/interface/state/forwarding-viable	Packet Forwarding Engine sensor for non-viable aggregated interface member links. This feature does not support non-LAG link members Starting in Junos OS Evolved Release 21.4R1, streaming statistics by means of gRPC and gNMI is supported on PTX10008 and PTX10016 routers.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/ike-security-associations/ike-security-association/routing-instance [name=' *routing-instance-name*]	Sensor for Internet Key Exchange (IKE) security statistics. When you configure a subscription request, use the reporting-interval parameter to configure the interval (in seconds) in which statistics are reported. Starting with Junos OS Release 18.1R1, MX Series routers are supported. • remote-ip • local-ip • number-ipsec-sa-created • number-ipsec-sa-deleted • number-ipsec-sa-rekey • exchange-type • in-bytes • in-packets • out-bytes • out-packets • delete-payload-received • delete-payload-transmitted • dpd-request-payload-received • dpd-request-payload-transmitted • dpd-response-payload-received • dpd-response-payload-transmitted • dpd-response-payload-missed • dpd-response-payload-maximum-delay

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• `dpd-response-seq-payload-missed` • `invalid-spi-notify-received` • `invalid-spi-notify-transmitted` • `routing-instance`
`/junos/kernel/tcpip/rtstock`	Sensor for kernel routing table socket (RTSOCK) information. Starting with Junos OS Release 19.3R1, EX9200, EX9251, EX9253, MX240, MX480, MX960, MX2010, MX2020, vMX, PTX1000, PTX10008, PTX10016, PTX3000 with RE-PTX-X8-64G, and PTX5000 with RE-PTX-X8-64G are supported. You can also add the following as the end path for /junos/kernel/rtsock/: • `total-error-cnt` • `total-veto-cnt`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/memory/`	Sensor for CPU memory. This sensor exports the CPU and memory utilization per process and CPU usage for threads per process. The current implementation is Linux-based; therefore, the export information and gathered output format differs significantly from this sensor's performance on previous platforms. Supported on MX Series routers with MPC10E-10C-MRATE and MPC10E-15C-MRATE line cards starting with Junos OS Release 19.3R1 for exporting telemetry information using gRPC services. This feature provides a different level of exported statistics in comparison to previous releases because it use the OpenConfig AFT model. Supported on MX2010 and MX2020 routers with MX2K-MPC11E line cards starting with Junos OS Release 20.1R1 for streaming telemetry information using gRPC services. Supported on EX2300, EX2300-MP, and EX3400 switches starting with Junos OS Release 20.2R1 and later for streaming telemetry information using gRPC services. Supported on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches starting with Junos OS Release 20.2R1 and later for INITIAL_SYNC statistics using gNMI services. The statistics exported from this sensor are found in the following operational mode commands: `show system info`, `show system processes`, and `show system cpu`.
`/junos/npu/memory`	Starting with Junos OS Release 19.1R1, periodic streaming on QFX10002 switches and PTX10002 routers is supported.
/junos/services/health-monitor/config/	Sensor for the health monitoring configuration. Starting with Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/services/health-monitor/data/	Sensor for health monitoring data. Starting with Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services.
`/junos/services/ip-tunnel[name='tunnel-name']/usage/counters[name='counter-name']/`	Sensor for Packet Forwarding Engine dynamic tunnels statistics. The statistics are used to report various network element performance metrics in a scalable and efficient way, providing visibility into Packet Forwarding Engine errors and drops. A timestamp indicating when the counters were last reset is included with all the exported data to allow collectors to determine if and when a reset event happened; for example, if the Packet Forwarding Engine hardware restarted. Exported statistics are similar to the output of the operational mode command `show nhdb hw dynamic-ip-tunnels`. Starting with Junos OS Release 17.4R1, MX Series devices are supported on gRPC services, with the exception of MX80 and MX104 routers. These routers support UDP export only for this sensor. To configure UDP export, include the sensor `/junos/services/ip-tunnel/usage/` in the sensor configuration statement at the `[edit services analytics]` hierarchy level.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/services/label-switched-path/usage/	Sensor for LSP statistics. On MX Series routers only, the following are also supported: bidirectional LSPs for ultimate-hop popping (UHP). Starting with Junos OS Release 17.2R1, QFX10000 switches and PTX1000 routers are also supported. Starting with Junos OS Release 17.3R1, EX9200 switches are also supported. Starting with Junos OS Release 17.4R1 on MX Series and PTX Series routers only, statistics for bypass LSPs are also exported. Previously, only statistics for ingress LSPs were exported. Starting with Junos OS Release 18.2R1, QFX5100, QFX5110, and QFX5200 switches are also supported. Starting with Junos OS Release 18.3R1, QFX5120-48Y and EX4650 switches are also supported. Starting with Junos OS Release 18.4R1, EX4600 switches are also supported. Starting with Junos OS Release 19.1R1, PTX10001-20C routers support RSVP bypass LSPs originating at the transit node Starting with Junos OS Release 19.1R1, periodic streaming on QFX10002 switches and PTX10002 routers is supported. Starting in Junos OS Evolved Release 19.1R1, PTX10003 routers are supported. Starting with Junos OS Release 19.2R1, ACX6360 routers are supported. Starting with Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services. Supported on QFX5200 switches starting with Junos OS Release 19.2R1 for streaming telemetry information using gNMI services. Starting with Junos OS Evolved Release 19.4R1, periodic streaming using gNMI services with PTX10003 routers is supported.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	Starting with Junos OS Evolved Release 20.2R1, periodic streaming using gRPC services with PTX10001 routers is supported. Periodic streaming is supported on QFX5120-48YM switches starting with Junos OS Release 20.4R1. For bypass LSPs, the following are exported: • Bypass LSP originating at the ingress router of the protected LSP. • Bypass LSP originating at the transit router of the protected LSP. • Bypass LSP protecting the transit LSP as well as the locally originated LSP. When the bypass LSP is active, traffic is exported both on the bypass LSP and the ingress (protected) LSP. **NOTE**: When you enable a sensor for LSP statistics only, you must also configure the sensor-based-stats (Junos Telemetry Interface) statement at the `[edit protocols mpls]` hierarchy level. MX Series routers should operate in enhanced mode. If not enabled by default, include either the `enhanced-ip` statement or the `enhanced-ethernet` statement at the `[edit chassis network-services]` hierarchy level.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/services/segment-routing/interface/ingress/usage/ /junos/services/segment-routing/interface/egress/usage/ /junos/services/segment-routing/sid/usage/ /junos/services/segment-routing/sid/egress/usage/	Sensors for aggregate segment routing traffic with IS-IS or OSPF. This sensor is supported on MX Series and PTX5000 routers starting with Junos OS Release 17.4R1. Starting with Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services. Statistics are exported separately for each routing instance. The first path exports inbound traffic. The second path exports outbound traffic. The third path exports inbound segment routing traffic for each segment identifier. The path **/junos/services/segment-routing/sid/egress/usage/** can be used to collect SID statistics for traffic travelling towards the core. **NOTE**: When you enable a sensor for segment routing statistics, you must also configure the sensor-based-stats (Junos Telemetry Interface) statement at the [edit protocols isis source-packet-routing] or [edit protocols ospf source-packet-routing] hierarchy level. All MX and PTX5000 routers with FPC3 onwards support enhanced mode. If enhanced mode is not enabled, configure either the enhanced-ip statement or the enhanced-ethernet statement at the [edit chassis network-services] hierarchy level. On PTX Series routers, configure the enhanced-mode statement at the [edit chassis network-services] hierarchy level. **NOTE**: Currently, MPLS labels correspond only to one instance, instance 0. Since each SID corresponds to a single instance_identifier, no aggregation is required to be done by the collector. The instance_identifier is stamped as 0. The following end points are supported: • /network-instances/network-instance/mpls/signaling-protocols/segment-routing/interfaces/interface/state/in-pkts • /network-instances/network-instance/mpls/signaling-protocols/segment-routing/interfaces/interface/state/in-octets

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /network-instances/network-instance/mpls/signaling-protocols/segment-routing/interfaces/interface/state/out-octets • /network-instances/network-instance/mpls/signaling-protocols/segment-routing/interfaces/interface/state/out-pkts • /network-instances/network-instance/mpls/aggregate-sid-counters/aggregate-sid-counter/state/in-octets • /network-instances/network-instance/mpls/aggregate-sid-counters/aggregate-sid-counter/state/in-pkts • /network-instances/network-instance/mpls/aggregate-sid-counters/aggregate-sid-counter/state/out-octets • /network-instances/network-instance/mpls/aggregate-sid-counters/aggregate-sid-counter/state/out-pkts • /network-instances/network-instance/mpls/interfaces/interface/sid-counters/sid-counter/state/in-octets • /network-instances/network-instance/mpls/interfaces/interface/sid-counters/sid-counter/state/in-pkts • /network-instances/network-instance/mpls/interfaces/interface/sid-counters/sid-counter/state/out-octets • /network-instances/network-instance/mpls/interfaces/interface/sid-counters/sid-counter/state/out-pkts • /network-instances/network-instance/mpls/interfaces/interface/sid-counters/sid-counter/forwarding-classes/forwarding-class/state/in-octets • /network-instances/network-instance/mpls/interfaces/interface/sid-counters/sid-counter/forwarding-classes/forwarding-class/state/in-pkts • /network-instances/network-instance/mpls/interfaces/interface/sid-counters/sid-counter/forwarding-classes/forwarding-class/state/out-octets

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /network-instances/network-instance/mpls/interfaces/interface/sid-counters/sid-counter/forwarding-classes/forwarding-class/state/out-pkts
/junos/services/segment-routing/sid/egress/usage/	Sensor for segment routing statistics based on segment identifier (SID).
/junos/services/segment-routing/sid/usage/	Sensors for aggregate segment routing traffic with IS-IS. This sensor is supported on PTX3000 routers and PTX5000 routers with FPC2 starting with Junos OS Release 19.1R1. Statistics are exported separately for each routing instance. The first path exports inbound traffic. The second path exports outbound traffic. The third path exports inbound segment routing traffic for each segment identifier. **NOTE**: When you enable a sensor for segment routing statistics, you must also configure the sensor-based-stats (Junos Telemetry Interface) statement at the `[edit protocols isis source-packet-routing]` hierarchy level.
/junos/services/segment-routing/traffic-engineering/ingress/usage	Packet Forwarding Engine sensor for ingress segment routing traffic engineering (SR-TE) statistics. /junos Starting in Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services. Starting in Junos OS Evolved Release 21.4R1,PTX10001-36MR, PTX10003, PTX10004, PTX10008,and PTX10016 routers are supported on gRPC and gNMI services.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/services/segment-routing/traffic-engineering/transit/usage`	Packet Forwarding Engine sensor for ingress segment routing traffic engineering statistics. Starting in Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services. Starting in Junos OS Evolved Release 21.4R1,PTX10001-36MR, PTX10003, PTX10004, PTX10008,and PTX10016 routers are supported on gRPC and gNMI services.

`/junos/services/segment-routing/traffic-engineering/tunnel/ingress/usage`
 	
`/junos/services/segment-routing/traffic-engineering/tunnel/transit/usage`
	Packet Forwarding Engine sensors for ingress and transit SR-TE statistics for uncolored LSPs.
	
	To configure SR-TE, see Configure SR-TE for Uncolored Ingress LSPs.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/services/segment-routing/traffic-engineering/tunnel/lsp/ingress/usage/ /junos/services/segment-routing/traffic-engineering/tunnel/lsp/transit/usage/	Sensor for Segment Routing Traffic Engineering (SR-TE) per Label Switched Path (LSP) route statistics. You can stream SR-TE telemetry statistics for uncolored SR-TE policies to an outside collector. Ingress statistics include statistics for all traffic steered by means of an SR-TE LSP. Transit statistics include statistics for traffic to the Binding-SID (BSID) of the SR-TE policy. To enable these statistics, include the **per-source per-segment-list** option at the [edit protocols source-packet-routing telemetry statistics] hierarchy level. Starting in Junos OS Release 20.1R1, MX Series and PTX Series routers support streaming statistics using gRPC services. Starting in Junos OS Release 20.2R1, MX240. MX480, MX960, MX2010, and MX2020 with MPC-10E or MPC-11E routers support streaming statistics using gRPC services. When a subscription is made to these resource paths, the following output format is displayed: • /mpls/signaling-protocols/segment-routing/sr-te-per-lsp-ingress-policies/sr-te-ingress-lsp-policy\[tunnel-name='srtelsp1' and source='st' and origin='0' and distinguisher='f' and lsp-name='sr1'\]/state/counters\[name='.*'\]/packets • /mpls/signaling-protocols/segment-routing/sr-te-per-lsp-transit-policies/sr-te-transit-lsp-policy\[tunnel-name='srtelsp1' and source='st' and origin='0' and distinguisher='f' and lsp-name='sr1'\]/state/counters\[name='.*'\]/packets For the output format above, the field source, values can be ST (static tunnel) or PC (PCEP tunnel). For the field lsp-name, the value is the transit output. Other fields, such as Origin and Distinguisher are fixed for uncolored tunnels.
/junos/system/cmerror/configuration	Sensor for error monitoring configuration. Starting in Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/system/cmerror/counters	Sensor for error monitoring counters. Starting in Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services.
/junos/system/linecard/bmon-sw/	Sensor for interface burst monitoring. Starting in Junos OS Evolved Release 19.3R1, QFX5220-128C and QFX5220-32CD switches are supported for streaming statistics on gRPC services. You can also add the following to the end of the path to stream specific statistics for interface burst monitoring: • `rx_bytes`-Total number of bytes received during the export interval. • `tx_bytes`-Total number of bytes transmitted during the export interval. • `start_ts`-Start timestamp for the data collection window. • `rx_peak_byte_rate`-Maximum bytes rate per millisecond received from all the sampling intervals in the export interval. • `rx_peak_ts`-Timestamp of the first burst. • `tx_peak_byte_rate`-Maximum bytes rate per millisecond, transmitted from all the sampling intervals in the export interval. • `tx_peak_byte_ts`-Timestamp of the first transmit burst.
/junos/system/linecard/cos/interface/interface-set/output/queue/	Sensor for logical interface (IFL)-set. The sensor streams queue statistics using Juniper proprietary gRPC and gNMI or by means of UDP. Zero suppression (suppressing zero values in statistics from streamed data) is also supported. Starting in Junos OS Release 22.3R1, MX204, MX240, MX304, MX480, MX960, MX2010, MX2020, MX10003, MX10004, MX10008, and MX10016 routers with Trio chipset EA, ZT, and YT-based fixed systems and modular systems linecards are supported.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/cpu/memory/`	Sensor for CPU memory. **NOTE**: On PTX Series routers, FPC1 and FPC2 are not supported. Supported on QFX10000 switches and PTX1000 routers starting with Junos OS Release 17.2R1. Supported on EX9200 switches starting with Junos OS Release 17.3R1. Supported on QFX5100, QFX5110, and QFX5200 switches starting with Junos OS Release 18.2R1. Supported on QFX5120-48Y and EX4650 switches starting with Junos OS Release 18.3R1. Supported on EX4600 switches starting with Junos OS Release 18.4R1. Periodic streaming is supported on QFX10002 switches and PTX10002 routers starting with Junos OS Release 19.1R1. Starting with Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services. Supported on QFX5200 switches starting with Junos OS Release 19.2R1 for streaming telemetry information using gNMI services. Periodic streaming using gRPC services is supported on EX4300-MP switches starting with Junos OS Release 19.4R1, Periodic streaming using gRPC services is supported on EX2300, EX2300-MP, and EX3400 switches starting with Junos OS Release 20.2R1. Periodic streaming is supported on QFX5120-48YM switches starting with Junos OS Release 20.4R1. Streaming statistics using Juniper proprietary gRPC is supported on M304 starting with Junos OS Release 22.4R1. You can also include the following to end of the resource path for CPU memory:

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• [name="mem-util-<*memory-name*>-size"]/value • [name="mem-util-<*memory-name*>-bytes-allocated"]/value • [name="mem-util-<*memory-name*>-utilization"]/value • [name="mem-util-<*memory-name*>-< *app-name*>-allocations"]/value • [name="mem-util-<*memory-name*>-< *app-name*>-frees"]/value • [name="mem-util-<*memory-name*>-< *app-name*>-allocations-failed"]/value

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/ddos/`	Distributed denial of service (DDoS) sensor. This sensor supports the Openconfig data model junos/ui/openconfig/yang/ and junos-ddos.yang. You can stream information using Juniper proprietary gRPC or UDP (native) export. There are 45 packet types for DDoS. To maintain a reasonably sized data stream, data is exported for all protocols that have seen traffic using the zero-suppression model. On QFX5000 platforms, multiple protocols can share the same CPU queue. DDoS configurations are applied at the CPU queue level. Consequently, DDoS statistics fetched from the CPU queue will return the aggregate value of all protocols using that queue. For example, if BGP, LDP, and RSVP protocols are using a particular CPU queue, but the DDoS limit is violated only by the BGP protocol, the DDoS violation reported will include all three protocols: BGP, LDP, and RSVP. This information will be exported to the collector with the DDoS sensor. Starting in Junos OS Release 22.1R1 EX4650, QFX5110, QFX5120-48Y, QFX5200 and QFX5210 switches are supported. Starting in Junos OS Evolved Release 22.3R1, PTX10001-36MR, PTX10003, PTX10004, PTX10008, PTX10016 routers are supported. You can also add the following leaves to the end of the path to stream specific statistics: • `group_name` • `group_id` • `protocol_name` • `protocol_id` • `location` • `received`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description

	• `arrive-policer`
	• `dropped-individual_policer`
	• `dropped_aggregate_policer`
	• `total_dropped`
	• `final_passed`
	• `arrival_rate`
	• `max_arrival_rate`
	• `pass_rate`
	• `policer_state`
	• `policer_violation_count`
	• `policer_violation_start_time`
	• `policer_violation_end_time`
	• `policer_violation_duration`
	
	The following packet types are supported:
	
	`------ --------- -------- -------- -----------------------------`
	`CMICQ  Channel   bwidth    burst     Qlen           Proto(s)`
	`------ ---------- -------- -------- ---------`
	`-----------------------------`
	`     0        3      500       10       200              uncls`
	`     4        1     4000      200       200           vchassis`
	`     7        3      500      200       200              vxlan`
	`     8        3     1500      200       200            localnh`
	`     9        3     1000      200       200          vcipc-udp`
	`    10        3     2000      200       200      sample-source`
	`    11        3     2000      200       200        sample-dest`
	`    12        3       50       10       200         l3mtu-`
	`fail,ttl,ip-opt.`
	`    14        3      100       10       200         garp-reply`
	`    15        3      500       10       200            fw-host`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	16 3 500 200 200 ndpv6 17 3 1000 200 200 dhcpv4v6 19 3 1500 200 200 ipmc-reserved 20 3 300 200 200 resolve 21 3 100 10 200 l3dest-miss 22 3 100 10 200 redirect 23 3 300 200 200 l3nhop 24 3 100 10 200 l3mc-sgvhit-icl 25 3 50 10 200 martian-address 26 3 1000 200 200 l2pt 27 3 50 10 200 urpf-fail 28 3 1000 300 300 ipmcast-miss 29 2 300 10 200 nonucast-switch 30 2 3000 200 200 rsvp,ldp,bgp 31 2 3000 200 200 unknown- l2mc,rip,ospf 32 2 1000 200 200 fip-snooping 33 2 1000 200 200 igmp 34 2 500 200 200 arp 35 2 1500 200 200 pim-data 36 2 1500 200 200 ospf-hello 37 2 1500 200 200 pim-ctrl 38 2 2000 200 200 isis 39 1 250 200 200 lacp 40 1 1200 200 200 bfd 41 1 100 10 200 ntp 42 1 500 200 200 vchassis 43 1 1000 200 200 stp,pvstp,lldp

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/system/linecard/environment/	Sensor for environmental statistics. When subscribing to the resource path /junos/system/linecard/environment, the prefix for the streamed path at the collector side was displaying as /junos/linecard/environment. This issue is resolved in Junos OS 23.1R1 and Junos OS Evolved 23.1R1 and the subscription path and the streamed path match to display /junos/system/linecard/environment. Supported on MX10008 routers starting with Junos OS Release 21.4R1 using Juniper proprietary gRPC. Supported on MX10004 routers starting with Junos OS Release 22.3R1 using Juniper proprietary gRPC. FPC environment sensor /junos/system/linecard[name=FPC0]/environment/ is supported on MX10004 routers starting with Junos OS Release 22.4R1 using Juniper proprietary gRPC and gNMI. You can stream the following endpoints: • /power-record/max-fpc-power /power-record/fpc-power • voltage-record/voltage-sensor-name • voltage-record/voltage-value • temp-sensor-name • temp-record/temp-value

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/fabric/`	Sensor for fabric statistics. Supported on MX10008 routers starting with Junos OS Release 22.1R1 using Juniper proprietary gRPC. Supported on MX10004 routers starting with Junos OS Release 22.4R1 using Juniper proprietary gRPC. Supported on PTX10001-36MR, PTX10003, PTX10004, PTX10008, and PTX10016 routers starting with Junos OS Evolved Release 22.4R1 using Juniper proprietary gRPC. Subscribe to this resource path to export the following statistics under the base path `/junos/fabric-statistics/fabric-message/edges/class-stats/transmit-counts/`: • packets • bytes • packets-per-second • bytes-per-second • drop-packets • drop-bytes • drop-packets-per-second • drop-bytes-per-second • queue-depth-average • queue-depth-current • queue-depth-peak • queue-depth-maximum • error-packets • error-packets-per-second

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	Supported on MX10008 routers starting with Junos OS Release 21.4R1 using Juniper proprietary gRPC.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/system/linecard/firewall/	Sensor for firewall filter counters and policer counters. Each line card reports counters separately. Supported on QFX10000 switches starting with Junos OS Release 17.2R1. Supported on PTX1000 routers and EX9200 switches starting with Junos OS Release 17.3R1. Supported on QFX5100, QFX5110, and QFX5200 switches starting with Junos OS Release 18.2R1. Supported on QFX5120-48Y and EX4650 switches starting with Junos OS Release 18.3R1. Supported on EX4600 switches starting with Junos OS Release 18.4R1. Starting with Junos OS Release 19.1R1, periodic streaming is supported on QFX10002 switches and PTX10002 routers. Starting in Junos OS Evolved Release 19.1R1, PTX10003 routers are supported. Starting in Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services. Supported on QFX5200 switches starting with Junos OS Release 19.2R1 for streaming telemetry information using gNMI services. Supported on MX240, MX480, and MX960 routers starting with Junos OS Release 19.3R1 for exporting telemetry information using gNMI services. This feature includes support to export telemetry data for integration with AFTTelemetry and LibTelemetry libraries with the OpenConfig model openconfig-aft. Periodic streaming using gRPC services with EX4300-MP switches is supported starting with Junos OS Release 19.4R1. Periodic streaming using gNMI services with PTX10003 routers is supported starting with Junos OS Evolved Release 19.4R1. Periodic streaming using gNMI services on MX2K-MPC11E line cards on MX2010 and MX2020 routers is supported starting with Junos OS Release 20.1R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	Periodic streaming using gRPC services is supported on EX2300, EX2300-MP, and EX3400 switches starting with Junos OS Release 20.2R1. INITIAL_SYNC statistics using gNMI services is supported on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches starting with Junos OS Release 20.2R1. Periodic streaming is supported on QFX5120-48YM switches starting with Junos OS Release 20.4R1. **NOTE**: Hierarchical policer statistics are collected for MX Series routers only. Traffic-class counter statistics are collected for PTX Series routers and QFX10000 switches only. Firewall counters are exported even if the interface to which the firewall filter is attached is operationally down. The following OpenConfig paths are supported: • `junos/firewall[name='`*`filter-name`*`']/timestamp` • `/junos/firewall[name='`*`filter-name`*`']/ memory-usage/[name='`*`memory-type`*`']/allocated` • `/junos/firewall[name='`*`filter-name`*`']/ counter/[name='`*`counter-name`*`']/packets`
`/junos/system/linecard/intf-exp/`	Interface express sensor. This sensor leverages statistics out of the physical interface sensor, providing faster and more frequent operational status statistics. Only the physical interfaces' operational status from the Flexible PIC Concentrator (FPC) is collected and reported. Statistics from the Routing Engine interface are not reported. Supported on PTX1000, PTX3000, PTX5000, and PTX10000 starting with Junos OS Release 18.1R1. Supported on MX960, MX2010, and MX2020 routers starting with Junos OS Release 19.3R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/interface/`	Packet Forwarding Engine sensor for physical interface traffic. **NOTE**: For PTX Series routers, for a specific interface, queue statistics are exported for each line card. For MX series routers, interface queue statistics are exported only from the slot on which an interface is configured. For Aggregated Ethernet interfaces, statistics are exported for the member physical interfaces. You must aggregate the counters at the destination server, or collector. If a physical interface is administratively down or operationally down, interface counters are not exported. Issuing an operational `clear` command, such as `clear interfaces statistics all`, does not reset statistics exported by the line card. Supported on PTX Series routers starting with Junos OS Release 15.1F3. Supported on MX Series routers starting with Junos OS Release 15.1F5. Supported on QFX10000 switches and PTX1000 routers starting with Junos OS Release 17.2R1. Supported on EX9200 switches and MX150 routers starting with Junos OS Release 17.3R1. Supported on QFX5100, QFX5110, and QFX5200 switches starting with Junos OS Release 18.2R1. Supported on QFX5120-48Y and EX4650 switches starting with Junos OS Release 18.3R1. Supported on EX4600 switches Starting with Junos OS Release 18.4R1. Periodic streaming is supported on QFX10002 switches and PTX10002 routers starting with Junos OS Release 19.1R1. Supported on MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches with Junos OS Release 19.2R1 on gRPC and gNMI services. Supported on MX240, MX480, and MX960 routers starting with Junos OS Release 19.3R1 for exporting telemetry information using gNMI services. This feature includes support to export telemetry

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	data for integration with AFTTelemetry and LibTelemetry libraries with the OpenConfig model openconfig-aft. Starting with Junos OS Release 19.4R1, periodic streaming using gRPC services with EX4300-MP switches is supported. Periodic streaming using gNMI services on MX2K-MPC11E line cards on MX2010 and MX2020 routers is supported starting with Junos OS Release 20.1R1. Periodic streaming using gRPC services is supported on EX2300, EX2300-MP, and EX3400 switches starting with Junos OS Release 20.2R1. INITIAL_SYNC statistics using gNMI services is supported on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches starting with Junos OS Release 21.4R1. Streaming statistics using gRPC services or gNMI services is supported on PTX10008 routers starting with Junos OS Release 20.2R1. Periodic streaming is supported on QFX5120-48YM switches starting with Junos OS Release 20.4R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description

`/junos/system/linecard/interface/logical/family/ipv4/usage/`
 	
`/junos/system/linecard/interface/logical/family/ipv6/usage/`
	Sensor for per-family logical interface input and output counters for IPv4 and IPv6 traffic.
	
	Streaming statistics using Juniper proprietary gRPC is supported on MX304 starting with Junos OS Release 22.4R1.
	
	Streaming statistics using Juniper proprietary gRPC is supported on MX10008 starting with Junos OS Release 21.4R1.
	
	Streaming statistics using Juniper proprietary gRPC is supported on MX Series and PTX Series routers using third-generation FPCs starting with Junos OS Release 21.2R1.
	
	Streaming statistics using Juniper proprietary gRPC is supported on MX10004 starting with Junos OS Release 22.3R1.
	
	Streaming of IPv6 counters supported on PTX10001-36MR, PTX10004, PTX10008 and PTX10016 routers starting with Junos OS Evolved Release 23.2R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/interface/logical/usage`	Packet Forwarding Engine sensor for logical interface statistics. **NOTE**: If a logical interface is operationally down, interface statistics continue to be exported. Issuing an operational `clear` command, such as `clear interfaces statistics all`, does not reset statistics exported by the line card. **NOTE**: If a logical interface is operationally down, interface statistics continue to be exported. Issuing an operational `clear` command, such as `clear interfaces statistics all`, does not reset statistics exported by the line card. **NOTE**: Locally injected packets from the Routing Engine are not exported. **NOTE**: Locally injected packets from the Routing Engine are not exported. Supported in Junos OS Release 15.1F5. Supported QFX10000 switches starting with on Junos OS Release 17.2R1. Supported on EX9200 switches and MX150 routers starting with Junos OS Release 17.3R1. Supported on QFX5100, QFX5110, and QFX5200 switches starting with Junos OS Release 18.2R1. Supported on QFX5120-48Y and EX4650 switches starting with Junos OS Release 18.3R1. Supported on EX4600 switches starting with Junos OS Release 18.4R1. Starting with Junos OS Release 19.1R1, periodic streaming is supported on QFX10002 switches and PTX10002 routers. Supported on MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches with Junos OS Release 19.2R1 on gRPC and gNMI services. Supported on QFX5200 switches starting with Junos OS Release 19.2R1 for streaming telemetry information using gNMI services.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	Supported on MX240, MX480, and MX960 routers starting with Junos OS Release 19.3R1 for exporting telemetry information using gNMI services. This feature includes support to export telemetry data for integration with AFTTelemetry and LibTelemetry libraries with the OpenConfig model openconfig-aft. Starting with Junos OS Release 19.4R1, periodic streaming using gRPC services with EX4300-MP switches is supported. Periodic streaming using gNMI services on MX2K-MPC11E line cards on MX2010 and MX2020 routers is supported starting with Junos OS Release 20.1R1. Periodic streaming using gRPC services is supported on EX3400 switches starting with Junos OS Release 20.2R1. INITIAL_SYNC statistics using gNMI services is supported on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches starting with Junos OS Release 20.2R1. Periodic streaming is supported on QFX5120-48YM switches starting with Junos OS Release 20.4R1. Supported on PTX10003 routers starting in Junos OS Evolved Release 22.3R1. Support includes the following sensors: • `/junos/system/linecard/interface/logical/usage/counters/in-pkts/state/value` • `/junos/system/linecard/interface/logical/usage/counters/out-pkts/state/value` • `/junos/system/linecard/interface/logical/usage/counters/in-octets/state/value` • `/junos/system/linecard/interface/logical/usage/counters/out-octets/state/value` Supported on virtual interfaces (lt, gr, si, lsp and ps) on MX204, MX480, MX960,MX10004, MX10008, MX10016, MX2010, and MX2020 routers starting in Junos OS Release 23.2R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/interface/queue/`	Sensor for interface queue statistics. Starting with Junos OS Release 18.3R1, when a subscription is made to `/interfaces` on MX, EX, QFX, PTX, and ACX7k platforms that support this feature, traffic and queue statistics are delivered in two separate sensors: • **/junos/system/linecard/interface/traffic/** • **/junos/system/linecard/interface/queue/** This can reduce the reap time for non-queue data for platforms supporting Virtual Output Queues (VOQ), such as PTX Series routers. Starting in Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services. Supported on MX240, MX480, and MX960 routers starting with Junos OS Release 19.3R1 for exporting telemetry information using gNMI services. This feature includes support to export telemetry data for integration with AFTTelemetry and LibTelemetry libraries with the OpenConfig model openconfig-aft. Periodic streaming using gNMI services on MX2K-MPC11E line cards on MX2010 and MX2020 routers is supported starting with Junos OS Release 20.1R1. INITIAL_SYNC statistics using gNMI services is supported on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches starting with Junos OS Release 20.2R1. Supported on ACX7100 and ACX7509 starting in Junos OS Evolved Release 22.2R1. Support includes transmitted counters for: • packets • bytes • red drop packets • red drop bytes

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• tail drop packets • tail drop bytes Starting in Junos OS Evolved Release 22.4R1 you can stream statistics for IPv4 and IPv6 traffic statistics using the resource path **/junos/system/linecard/interface/traffic/**. Support includes transmitted counters for: • if_in_ipv4pkts • if_out_ipv4pkts • if_in_ipv6pkts • if_out_ipv6pkts Supported on virtual interfaces (lt, gr, si, lsp and ps) on MX204, MX480, MX960, MX10004, MX10008, MX10016, MX2010, and MX2020 routers starting in Junos OS Release 23.2R1.
`/junos/system/linecard/node-slicing/af-fab-stats/`	Sensor to export abstracted fabric (AF) interface-specific load-balancing and fabric queue statistics. This sensor is only supported for in node virtualization configurations on MX routers with an AF Interface as the connecting link between guest network functions (GNFs). The sensor also reports aggregated statistics across all AF interfaces hosted on a source packet forwarding engine of local guest GNFs along with the fabric statistics for all traffic ingressing from and egressing to the fabric from that the packet forwarding engine. Supported on MX480, MX960, MX2010, MX2020, MX2008 and MX-ELM routers with Junos OS Release 18.4R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/npu/memory/`	Sensor for network processing unit (NPU) memory. You can also add the following leaves to the end of the path to stream specific statistics: • `resource_name` • `size` • `allocated` • `utilization` • `lower-threshold` • `upper-threshold` • `health` **NOTE**: Collecting telemetry statistics using the NPU memory sensor can cause high CPU cycles when gathering the MPLS ingress statistics (MPLS_Entry leaf). This, in turn, creates performance issues for the packet forwarding engine process. To correct this problem, MPLS ingress statistics are initially collected as a baseline. Statistics are updated after 30 seconds if a route is added or deleted. Otherwise, if there is no route change, statistics are fetched every hour. Supported on EX4650, QFX5110, QFX5120-48Y, QFX5200, and QFX5210 switches starting with Junos OS Release 21.4R1 for exporting telemetry information using gRPC or gNMI services. Supported on QFX5130, QFX5700, QFX5220-32CD, QFX5220-128C, QFX5130-48C, QFX5130-48CM, QFX5130E-32CD, QFX5230-64CD, QFX5240-64QD, and QFX5240-64QD switches starting with Junos OS Release 24.4R1 for exporting telemetry information using gRPC or gNMI services.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/npu/memory/`	Sensor for network processing unit (NPU) memory. Supported on MX Series routers with MPC10E-10C-MRATE and MPC10E-15C-MRATE line cards starting with Junos OS Release 19.3R1 for exporting telemetry information using gRPC services. This feature provides a different level of exported statistics in comparison to previous releases because it use the OpenConfig AFT model. Supported on MX2010 and MX2020 routers with MX2K-MPC11E line cards starting with Junos OS Release 20.1R1 for streaming telemetry information using gRPC services. Supported on MX304 routers using Juniper proprietary gRPC and gNMI starting with Junos OS Release 22.4R1. You can also add the following to the end of the path to stream specific statistics for NPU memory: • `mem-util-edmem-size` • `mem-util-edmem-allocated` • `mem-util-edmem-utilization` • `mem-util-idmem-size` • `mem-util-idmem-allocated` • `mem-util-idmem-utilization` • `mem-util-bulk-dmem-size` • `mem-util-bulk-dmem-allocated` • `mem-util-bulk-dmem-utilization` • `mem-util-next-hop-edmem-size` • `mem-util-next-hop-edmem-allocated` • `mem-util-next-hop-edmem-utilization` • `mem-util-next-hop-bulk-dmem-size`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• mem-util-next-hop-bulk-dmem-allocated • mem-util-next-hop-bulk-dmem-utilization • mem-util-next-hop-idmem-size • mem-util-next-hop-idmem-allocated • mem-util-next-hop-inline-services-free-count • mem-util-next-hop-mobile:-timing-profile-bytes-allocated • mem-util-next-hop-mobile:-timing-profile-allocation-count • mem-util-next-hop-mobile:-timing-profile-free-count • mem-util-next-hop-packet-reassembly-(rw)-bytes-allocated • mem-util-next-hop-packet-reassembly-(rw)-allocation-count • mem-util-next-hop-packet-reassembly-(rw)-free-count • mem-util-next-hop-packet-reassembly---persistent-(rw)-bytes-allocated • mem-util-next-hop-packet-reassembly---persistent-(rw)-allocation-count • mem-util-next-hop-packet-reassembly---persistent-(rw)-free-count • mem-util-next-hop-ml-bundle-bytes-allocated • mem-util-next-hop-ml-bundle-allocation-count • mem-util-next-hop-ml-bundle-free-count • mem-util-next-hop-ddos-scfd-params-bytes-allocated • mem-util-next-hop-ddos-scfd-params-allocation-count • mem-util-next-hop-ddos-scfd-params-free-count • mem-util-next-hop-vbf-bytes-allocated

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• mem-util-next-hop-vbf-allocation-count • mem-util-next-hop-vbf-free-count • mem-util-next-hop-ptp-ieee-1588-nhs-bytes-allocated • mem-util-next-hop-ptp-ieee-1588-nhs-allocation-count • mem-util-next-hop-ptp-ieee-1588-nhs-free-count • mem-util-next-hop-cos-bytes-allocated • mem-util-next-hop-cos-allocation-count • mem-util-next-hop-cos-free-count • mem-util-next-hop-inline-hash-sessions-bytes-allocated • mem-util-next-hop-inline-hash-sessions-allocation-count • mem-util-next-hop-inline-hash-sessions-free-count • mem-util-next-hop-inline-mdi-bytes-allocated • mem-util-next-hop-inline-mdi-allocation-count • mem-util-next-hop-inline-mdi-free-count • mem-util-next-hop-cos-enhanced-priority-bytes-allocated • mem-util-next-hop-cos-enhanced-priority-allocation-count • mem-util-next-hop-cos-enhanced-priority-free-count • mem-util-firewall-fw-bytes-allocated • mem-util-firewall-fw-allocation-count • mem-util-firewall-fw-free-count • mem-util-counters-fw-counter-bytes-allocated • mem-util-counters-fw-counter-allocation-count

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• `mem-util-counters-fw-counter-free-count` • `mem-util-counters-fw-policer-bytes-allocated` • `mem-util-counters-fw-policer-allocation-count` • `mem-util-counters-fw-policer-free-count` • `mem-util-counters-ifd-error-cntr-bytes-allocated` • `mem-util-counters-ifd-error-cntr-allocation-count` • `mem-util-counters-ifd-error-cntr-free-count` • `mem-util-counters-nh-cntr-bytes-allocated` • `mem-util-counters-nh-cntr-allocation-count` • `mem-util-counters-nh-cntr-free-count` • `mem-util-counters-ifl-cntr-bytes-allocated` • `mem-util-counters-ifl-cntr-allocation-count` • `mem-util-counters-ifl-cntr-free-count` • `mem-util-counters-bridge-domain-counter0-bytes-allocated` • `mem-util-counters-bridge-domain-counter0-allocation-count` • `mem-util-counters-bridge-domain-counter0-free-count` • `mem-util-counters-bridge-domain-counter0-free-count` • `mem-util-counters-bridge-domain-cntr-bytes-allocated` • `mem-util-counters-bridge-domain-cntr-allocation-count` • `mem-util-counters-bridge-domain-cntr-free-count` • `mem-util-counters-sample-inline-params-bytes-allocated` • `mem-util-counters-sample-inline-params-allocation-count`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• mem-util-counters-sample-inline-params-free-count • mem-util-counters-services-counters-bytes-allocated • mem-util-counters-services-counters-allocation-count • mem-util-counters-services-counters-free-count • mem-util-counters-exception-counter-bytes-allocated • mem-util-counters-exception-counter-allocation-count • mem-util-counters-exception-counter-free-count • mem-util-counters-issu-policer-bytes-allocated • mem-util-counters-issu-policer-allocation-count • mem-util-counters-issu-policer-free-count • mem-util-counters-ddos-scfd-counters-bytes-allocated • mem-util-counters-ddos-scfd-counters-allocation-count • mem-util-counters-ddos-scfd-counters-free-count • mem-util-counters-ip-reassembly-counter-bytes-allocated • mem-util-counters-ip-reassembly-counter-allocation-count • mem-util-counters-ip-reassembly-counter-free-count • mem-util-hash-hash-edmem-overhead-bytes-allocated • mem-util-hash-hash-edmem-overhead-bytes-allocated • mem-util-hash-hash-edmem-overhead-bytes-allocated • mem-util-hash-hash-edmem-overhead-bytes-allocated • mem-util-hash-hash-edmem-overhead-bytes-allocated • mem-util-hash-hash-edmem-overhead-allocation-count

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• `mem-util-hash-hash-edmem-overhead-free-count` • `mem-util-hash-hash-edmem-bkt-bytes-allocated` • `mem-util-hash-hash-edmem-bkt-allocation-count` • `mem-util-hash-hash-edmem-bkt-free-count` • `mem-util-hash-hash-edmem-rec-bytes-allocated` • `mem-util-hash-hash-edmem-rec-allocation-count` • `mem-util-hash-hash-edmem-rec-free-count` • `mem-util-hash-hash-edmem-sideband-bytes-allocated` • `mem-util-hash-hash-edmem-sideband-allocation-count` • `mem-util-hash-hash-edmem-sideband-free-count` • `mem-util-hash-hash-dmem-bkt-bytes-allocated` • `mem-util-hash-hash-dmem-bkt-allocation-count` • `mem-util-hash-hash-dmem-bkt-free-count` • `mem-util-hash-hash-dmem-rec-bytes-allocated` • `mem-util-hash-hash-dmem-rec-allocation-count` • `mem-util-hash-hash-dmem-rec-free-count` • `mem-util-hash-hash-dmem-sideband-bytes-allocated` • `mem-util-hash-hash-dmem-sideband-allocation-count` • `mem-util-hash-hash-dmem-sideband-free-count` • `mem-util-encaps-ueid-bytes-allocated` • `mem-util-encaps-ueid-allocation-count` • `mem-util-encaps-ueid-free-count`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• mem-util-encaps-ueid-shared-bytes-allocated • mem-util-encaps-ueid-shared-bytes-allocated • mem-util-encaps-ueid-shared-allocation-count • mem-util-encaps-ueid-shared-free-count • mem-util-encaps-fabric-bytes-allocated • mem-util-encaps-fabric-allocation-count • mem-util-encaps-fabric-free-count • mem-util-services-nh-inline-jflow-sample-rr-(svcs)-bytes-allocated • mem-util-services-nh-inline-jflow-sample-rr-(svcs)-allocation-count • mem-util-services-nh-inline-jflow-sample-rr-(svcs)-free-count • mem-util-services-nh-inline-jflow-sample-nh-(svcs)-bytes-allocated • mem-util-services-nh-inline-jflow-sample-nh-(svcs)-allocation-count • mem-util-services-nh-inline-jflow-sample-nh-(svcs)-free-count

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/npu/memory/`	Sensor for network processing unit (NPU) memory, NPU memory utilization, and total memory available for each memory type. Supported on QFX10000 switches and PTX1000 routers starting with Junos OS Release 17.2R1. Supported on EX9200 switches starting with Junos OS Release 17.3R1. **NOTE**: Starting with Junos Release 17.4R1, FPC1 and FCP2 on PTX Series routers export data for NPU memory and NPU memory utilization. Previously, this sensor was supported only on FPC 3. Starting with Junos OS Release 18.3R1, EX4650 switches are supported. Starting with Junos OS Release 19.1R1, periodic streaming on PTX10002 routers is supported. Starting in Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers and PTX1000 and PTX10000 routers are supported on gRPC and gNMI services. The OpenConfig path is `/components/component[name="FPC<fpc-id>:NPU<npu-id>"] /properties/property/` You can also add the following to the end of the path to stream specific statistics for NPU memory: • `[name="mem-util-<memory-name>-size"]/value` • `[name="mem-util-<memory-name>-bytes-allocated"]/value` • `[name="mem-util-<memory-name>-utilization"]/value` • `[name="mem-util-<partition-name>-< app-name>-allocation-count"]/value` • `[name="mem-util-<partition-name>-< app-name>-bytes-allocated"]/value` • `[name="mem-util-<partition-name>-< app-name>-free-count"]/value` You can also add the following to the end of the path to stream specific statistics for NPU:

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• [name="util-<*memory-name*>-average-util"]/value • [name="util-<*memory-name*>-highest-util"]/value • [name="util-<*memory-name*>-lowest-util"]/value • [name="util-<*memory-name*>-average-cache-hit-rate"]/value • [name="util-<*memory-name*>-lowest-cache-hit-rate"]/value • [name="util-<*packet-identifier*>-rate"]/value You can also export the following statistics for NPU memory for PTX routers only • pfe_name • combined_pool_name • combined_size • combined_usage_cnt • combined_utilization • global_pool_name • global_usage_cnt • global_alloc_cnt • global_free_cnt • local_pool_name • local_usage_cnt • local_alloc_cnt • local_free_cnt

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/npu/memory/`	Sensor for NPU Memory utilization statistics. Shown below, statistics are exported for the default FPC (**FPC0**). Multiples FPCs are supported. The component values and property values are names (like interface names). Starting in Junos OS Evolved Release 19.4R1, streaming statistics using gRPC and gNMI services on PTX10008 routers is supported. Starting in Junos OS Release 20.2R1, INITIAL_SYNC statistics using gNMI services on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches are supported. Starting in Junos OS Evolved Release 21.4R1, streaming statistics by means of gRPC and gNMI is supported on PTX10001-36MR, PTX10004, and PTX10008 routers. Supported on PTX10003 routers starting with Junos OS Release 22.3R1. Statistics are exported in the following format: `/components/component[name='FPC*:NPU*']/properties/property[name=<>]/state/value` The list below shows the property names: • `/components-memory/component[name='FPC0:NPU17']/` • `/components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-epp-mapid-size']/` • `/components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-epp-mapid-allocated']/` • `/components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-epp-mapid-utilization']/` • `/components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-l2domain-size']/` • `/components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-l2domain-allocated']/`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-l2domain-utilizationn']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-tunnell2domainhash00-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-tunnell2domainhash00-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-tunnell2domainhash00-utilization']/ • :/components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-tunnell2domainhash10-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-tunnell2domainhash10-allocatedd']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-tunnell2domainhash10-utilization']/ • :/components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-slu-my-mac-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-slu-my-mac-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-slu-my-mac-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-dlu-idb-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-dlu-idb-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-kht-dlu-idb-utilization']/ } • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-final-size']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-final-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-final-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-remap-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-remap-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-remap-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-refbits-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-refbits-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-refbits-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-nh-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-nh-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-nh-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-mpls-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-mpls-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name=' mem-util-jnh-mpls-utilization']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-loadbal-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-loadbal-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-loadbal-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-egress-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-egress-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jnh-egress-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jtree-memory-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jtree-memory-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-jtree-memory-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-vfilter-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-vfilter-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-vfilter-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-phyfilter-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-phyfilter-allocated']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-phyfilter-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-action-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-action-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-action-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-tcam-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name=' mem-util-flt-tcam-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-tcam-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-0-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-0-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-0-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-1-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-1-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-1-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-2-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-2-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-2-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-3-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-3-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-3-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-4-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-4-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-fcv-blk-4-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-scv-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-scv-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-scv-utilization']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-0-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-0-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-0-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-1-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-1-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-1-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-2-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-2-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-2-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-3-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-3-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-3-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-4-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-4-allocated']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-4-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-5-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-5-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-5-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-6-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-6-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-6-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-7-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-7-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-0-bank-7-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name=' mem-util-flt-beta-1-bank-0-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-0-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-0-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-1-size']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-1-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-1-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-2-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-2-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-2-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-3-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-3-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-3-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-4-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-4-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-4-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-5-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-5-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-5-utilization']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-6-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-6-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-6-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-7-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-7-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-beta-1-bank-7-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-kht-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-kht-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-kht-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-bft-0-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-bft-0-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-bft-0-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-plt-size']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-plt-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-0-plt-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-kht-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-kht-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-kht-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-bft-0-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-bft-0-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-bft-0-utilization']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-plt-size']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-plt-allocated']/ • /components-memory/component[name='FPC0:NPU17']/properties/property[name='mem-util-flt-alpha-1-plt-utilization']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/npu/utilization`	Sensor for NPU utilization on the Packet Forwarding Engine. Packet Forwarding Engine utilization is exported exported as a percentage using input notifications. The following packet statistics are also exported as part of this field: • Loopback (pps) • Recirculation (pps) • WAN and host inject (pps) • ASIC to host (pps) Shown below, statistics are exported for the default FPC (**FPC0**). Multiples FPCs are supported. The component values and property values are names (like interface names). Starting in Junos OS Evolved Release 19.4R1, streaming statistics using gRPC and gNMI services on PTX10008 routers is supported. The following statistics are exported: • `/components-utilization/component[name='FPC0:NPU17'` • `/components-utilization/component[name='FPC0:NPU17']/properties/property[name='util-metric']` • `/components-utilization/component[name='FPC0:NPU17']/properties/property[name='util-Loopback-packet-rate']` • `components-utilization/component[name='FPC0:NPU17']/properties/property[name='util-Recirculation-packet-rate']` • `/components-utilization/component[name='FPC0:NPU17']/properties/property[name='util-Wan and Host inject-packet-rate']` • `/components-utilization/component[name='FPC0:NPU17']/properties/property[name='util-ASIC to host-packet-rate']`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/npu/utilization/`	Packet Forwarding Engine sensor for NPU processor utilization. Supported on MX Series routers with MPC10E-10C-MRATE and MPC10E-15C-MRATE line cards starting with Junos OS Release 19.3R1 for streaming telemetry information using gRPC services. This feature provides a different level of exported statistics in comparison to previous releases because it uses the OpenConfig AFT model. Supported on MX2010 and MX2020 routers with MX2K-MPC11E line cards starting with Junos OS Release 20.1R1 for streaming telemetry information using gRPC services. Supported on MX304 routers using Juniper proprietary gRPC and gNMI starting with Junos OS Release 22.1R1. Supported on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches starting with Junos OS Release 20.2R1 and later for INITIAL_SYNC statistics using gNMI services. You can also include the following to the end of the resource path for NPU utilization: • `util-metric` • `util-Disp 0 Pkts-packet-rate` • `util-Disp 0 Pkts-average-instructions-per-packet` • `util-Disp 0 Pkts-average-wait-cycles-per-packet` • `util-Disp 0 Pkts-average-cycles-per-packet` • `util-Disp 1 Pkts-packet-rate` • `util-Disp 1 Pkts-average-instructions-per-packet` • `util-Disp 1 Pkts-average-wait-cycles-per-packet` • `util-Disp 1 Pkts-average-cycles-per-packet` • `util-Disp 2 Pkts-packet-rate`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• `util-Disp 2 Pkts-average-instructions-per-packet` • `util-Disp 2 Pkts-average-wait-cycles-per-packet` • `util-Disp 2 Pkts-average-cycles-per-packet` • `util-Disp 3 Pkts-packet-rate` • `util-Disp 3 Pkts-average-instructions-per-packet` • `util-Disp 3 Pkts-average-wait-cycles-per-packet` • `util-Disp 3 Pkts-average-cycles-per-packet` • `mem-util-EDMEM-average-util` • `mem-util-EDMEM-highest-util` • `mem-util-EDMEM-lowest-util` • `mem-util-EDMEM-average-cache-hit-rate` • `mem-util-EDMEM-highest-cache-hit-rate` • `mem-util-EDMEM-lowest-cache-hit-rate` • `mem-util-IDMEM-average-util` • `mem-util-IDMEM-highest-util` • `mem-util-IDMEM-lowest-util` • `mem-util-IDMEM-average-cache-hit-rate` • `mem-util-IDMEM-highest-cache-hit-rate` • `mem-util-IDMEM-lowest-cache-hit-rate` • `mem-util-Bulk DMEM-average-util` • `mem-util-Bulk DMEM-highest-util` • `mem-util-Bulk DMEM-lowest-util`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• `mem-util-Bulk DMEM-average-cache-hit-rate` • `mem-util-Bulk DMEM-highest-cache-hit-rate` • `mem-util-Bulk DMEM-lowest-cache-hit-rate`
`/junos/system/linecard/npu/utilization/`	Packet Forwarding Engine sensor for NPU processor utilization. Periodic streaming is supported on PTX10002 routers starting with Junos OS Release 19.1R1. Starting with Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers and PTX1000 and PTX10000 routers are supported on gRPC and gNMI services. Starting in Junos OS Evolved Release 21.4R1, streaming statistics by means of gRPC and gNMI is supported on PTX10001-36MR, PTX10004, and PTX10008 routers.
`/junos/system/linecard/optical`	Sensor for optical alarms. Configure this sensor for `et-`*`type-fpc/pic/port`* (100-Gigabit Ethernet) interfaces. Supported on ACX6360 Universal Metro, MX Series, and PTX Series routers with a CFP2-DCO optics module starting with Junos OS Release 18.3R1. This module provides a high-density, long-haul OTN transport solution with MACSec capability. Supported on MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches starting with Junos OS Release 19.2R1 on gRPC and gNMI services.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/otn`	Sensor for G.709 optical transport network (OTN) alarms. Configure this sensor on `ot-`*`type-fpc/pic/port`* interfaces. Supported on ACX6360 Universal Metro, MX Series, and PTX Series routers with a CFP2-DCO optics module starting with Junos OS Release 18.3R1. This module provides a high-density, long-haul OTN transport solution with MACSec capability. Supported on MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches starting with Junos OS Release 19.2R1 on gRPC and gNMI services.
`/junos/system/linecard/packet/usage/`	Sensor for Packet Forwarding Engine error and drop statistics. Use these statistics to optimize traffic engineering and improve your network design. When you include the resource path `/junos/system/linecard/packet/usage/` in a subscription, statistics are streamed in the format: `/components/component[name='FPC0:NPU3']/properties/property[name='hwds-dlu-not-routable']/state/value` Supported on PTX1000 and PTX5000 routers and QFX10002-60C switches using Juniper proprietary gRPC starting with Junos OS Release 22.1R1. Supported on PTX10003 routers starting with Junos OS Evolved Release 22.3R1.
`/junos/system/linecard/page-drops/page-drop/`	Sensor for CoS support. Use this sensor to stream CoS page-drop counters and interface details from a device to a collector. Page drop statistics include page drop counter, interface name and queue details. Supported on PTX5000 routers starting with Junos OS Release 22.2R1. Supported on PTX10003 routers starting with Junos OS Evolved Release 22.3R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/system/linecard/qmon-sw/	Sensor for congestion and latency monitoring statistics. Supported on QFX5100, QFX5110, and QFX5200 switches starting with Junos OS Release 18.2R1. Supported on QFX5120-48Y and EX4650 switches starting with Junos OS Release 18.3R1. Supported on EX4600 switches starting with Junos OS Release 18.4R1. Supported on MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches starting with Junos OS Release 19.2R1 on gRPC and gNMI services. Supported on QFX5200 switches starting with Junos OS Release 19.2R1 for streaming telemetry information using gNMI services. Periodic streaming using gRPC services with EX4300-MP switches is supported starting with Junos OS Release 19.4R1. Periodic streaming using gRPC services is supported on EX3400 switches starting with Junos OS Release 20.2R1. INITIAL_SYNC statistics using gNMI services is supported on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches starting with Junos OS Release 20.2R1. Periodic streaming is supported on QFX5120-48YM switches starting with Junos OS Release 20.4R1. Periodic streaming is supported on PTX5000, PTX1000, PTX10002, PTX10008, and PTX10016 routers and QFX10002, QFX10008, and QFX10016 switches starting with Junos OS Release 21.2R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/junos/system/linecard/services/inline-jflow`	Sensor for inline active flow monitoring services statistics. Supported on MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches starting with Junos OS Release 19.2R1 on gRPC and gNMI services. When configuring inline active flow monitoring in Junos, you can apply version 9 or IPFIX flow templates to define a flow record template suitable for IPv4 or IPv6 MPLS and bridging traffic. For more information, see https://www.juniper.net/documentation/us/en/software/junos/flow-monitoring/topics/concept/services-configuring-flow-aggregation-to-use-version-9-flow-templates.html. Supported on MX Series operating with MPC10E-15C-MRATE line-rate cards starting with Junos OS Release 19.2R1. Supported on MX240, MX480, and MX960 routers starting with Junos OS Release 19.3R1 for exporting telemetry information using gNMI services. This feature includes support to export telemetry data for integration with AFTTelemetry and LibTelemetry libraries with the OpenConfig model openconfig-aft. Periodic streaming using gNMI services on MX2K-MPC11E line cards on MX2010 and MX2020 routers is supported starting with Junos OS Release 20.1R1. Periodic streaming using gRPC services on PTX10008 routers is supported starting with Junos OS Evolved Release 20.1R1.
/network-instances/network-instance[instance-name='name']/protocols/protocol/evpn/irb-interfaces/	Local integrated routing and bridging (IRB) interface information sensor. Use the https://apps.juniper.net/ydm-explorer/ tool to see leafs for this resource path. Starting with Junos OS Release 20.2R1, streaming statistics is supported using gRPC services with QFX5100, QFX5110, QFX5120, QFX5200, QFX10002-60C, QFX10002, QFX10008, and QFX10016 switches.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/network-instances/network-instance[instance-name='name']/protocols/protocol/evpn/vxlan-tunnel-end-point/	Overlay VX-LAN tunnel information sensor. This sensor also delivers VTEP information ON_CHANGE leafs: • `source_ip_address` • `remote_ip_address` • `status` • `mode` • `nexthop-index` • `event-type` • `source-interface` Starting with Junos OS Release 20.2R1, streaming statistics is supported using gRPC services with QFX5100, QFX5110, QFX5120, QFX5200, QFX10002-60C, QFX10002, QFX10008, and QFX10016 switches.
/network-instances/network-instance[instance-name='name']/mac_db/entries/entry/	EVPN MAC table information sensor. Use the Telemetry Explorer tool to see leafs for this resource path. Starting with Junos OS Release 20.2R1, streaming statistics is supported using gRPC services with QFX5100, QFX5110, QFX5120, QFX5200, QFX10002-60C, QFX10002, QFX10008, and QFX10016 switches.
/network-instances/network-instance[instance-name='name']/macip_db/entries/entry/	MAC-IP or ARP-ND table sensor. Use the Telemetry Explorer tool to see leafs for this resource path. Starting with Junos OS Release 20.2R1, streaming statistics is supported using gRPC services with QFX5100, QFX5110, QFX5120, QFX5200, QFX10002-60C, QFX10002, QFX10008, and QFX10016 switches.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/system/linecard/optics/	Sensor for various optical interface performance metrics, such as transmit and receive power levels. The following leaves streamed with the /junos/system/linecard/optics/ resource path return a value of -Inf dB milliwatt (dBm) when the power is 0 milliwatt (mW)), To view these statistics from the Junos CLI, use the operational mode command **show interface diagnostics optics**. • /interfaces/interface/optics/laser_output_power_high_alarm_threshold_dbm • /interfaces/interface/optics/laser_output_power_low_alarm_threshold_dbm • /interfaces/interface/optics/laser_output_power_high_warning_threshold_dbm • /interfaces/interface/optics/laser_output_power_low_warning_threshold_dbm • /interfaces/interface/optics/laser_rx_power_high_alarm_threshold_dbm • /interfaces/interface/optics/laser_rx_power_low_alarm_threshold_dbm • /interfaces/interface/optics/laser_rx_power_high_warning_threshold_dbm • /interfaces/interface/optics/laser_rx_power_low_warning_threshold_dbm • /interfaces/interface/optics/lanediags/lane/lane_laser_output_power_dbm • /interfaces/interface/optics/ lanediags/lane/lane_laser_receiver_power_dbm The following resource paths are also supported on MX10004 starting with Junos OS Release 22.3R1:

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• `/junos/system/linecard/optics/optics-diag[if-name =]` • `/junos/system/linecard/optics/optics-diag/if-name` • `/junos/system/linecard/optics/optics-diag/snmp-if-index` MX10004 routers support these endpoints: • `module_temp` • `module_temp_high_alarm_threshold` • `module_temp_low_alarm_threshold` • `module_temp_high_warning_threshold` • `module_temp_low_warning_threshold` • `laser_output_power_high_alarm_threshold_dbm` • `laser_output_power_low_alarm_threshold_dbm` • `laser_output_power_high_warning_threshold_dbm` • `laser_output_power_low_warning_threshold_dbm` • `laser_rx_power_high_alarm_threshold_dbm` • `laser_rx_power_low_alarm_threshold_dbm` • `laser_rx_power_high_warning_threshold_dbm` • `laser_rx_power_low_warning_threshold_dbm` • `laser_bias_current_high_alarm_threshold` • `laser_bias_current_low_alarm_threshold` • `laser_bias_current_high_warning_threshold` • `laser_bias_current_low_warning_threshold` • `module_temp_high_alarm`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• `module_temp_low_alarm` • `module_temp_high_warning` • `module_temp_low_warning` Supported on QFX10000 switches starting with Junos OS Release 17.2R1. Supported on PTX1000 routers and EX9200 switches starting with Junos OS Release 17.3R1. Supported on EX4650 switches starting with Junos OS Release 18.3R1. Supported on MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches starting with Junos OS Release 19.2R1 on gRPC and gNMI services. Supported on MX10 routers, PTX1000 and PTX10000 routers, and QFX5100 and QFX5200 switches starting with Junos OS Release 19.2R1 on gRPC and gNMI services. Supported on MX10008 routers starting with Junos OS Release 22.1R1 using Juniper proprietary gRPC. Supported on MX10004 routers starting with Junos OS Release 22.3R1 using Juniper proprietary gRPC. Supported on ACX7100-32C, ACX7100-48L, and ACX7024 routers starting with Junos OS Evolved Release 22.3R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/mpls/lsps-constrained-path/tunnels/tunnel[name='*foo-name*',source='*foo-source*']/p2p-tunnel-attributes/p2p-primary-paths[name='*foo-path*']/state/name	Sensor to export the path name for ingress point-to-point LSPs, point-to-multipoint LSPs, bypass LSPs, and dynamically created LSPs. This sensor is supported on indicated platforms up to and including Junos OS Release 17.3R1. See the following resource paths for LSP support in Junos OS Release 17.4R1 and higher: • /network-instances/network-instance[name='*instance-name*']/mpls/lsps-constrained-path/tunnels/tunnel/p2p-tunnel-attributes/p2p-primary-paths/ • /network-instances/network-instance[name='*instance-name*']/mpls/signaling-protocols/rsvp-te/sessions/session/state/notify-status Supported on PTX Series routers, MX Series routers , and QFX10002, QFX10008, and QFX10016 switches starting with Junos OS Release 17.2R1.
/mpls/lsps-constrained-path/tunnels/tunnel[name='*foo-name*',source='*foo-source*']/p2p-tunnel-attributes/p2p-primary-paths[name='*foo-path*']/lsp-instances[index='*local-index*']/state/	Sensor to export LSP properties for ingress point-to-point LSPs, point-to-multipoint LSPs, bypass LSPs, and dynamically created LSPs Supported on PTX Series routers, MX Series routers, and QFX10002, QFX10008, and QFX10016 switches starting with Junos OS Release 17.2R1. The following end paths are also supported for the resource path: • bandwidth • metric • max-average-bandwidth • explicit-route-objects • record-route-objects
/mpls/signaling-protocols/ldp/lsp-transit-policies/lsp-transit-policy/state/counters	Sensor to export statistics for LDP LSP transit traffic. Supported on MX Series routers starting with Junos OS Release 20.2R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/mpls/signaling-protocols/ldp/lsp-ingress-policies/lsp-ingress-policy/state/counters`	Sensor to export statistics for LDP LSP ingress traffic. Supported on MX Series routers starting with Junos OS Release 20.2R1.
`/mpls/signaling-protocols/ldp/p2mp-lsps/p2mp-lsp/state/counters`	Sensor to export statistics for multipoint LDP LSP traffic. Supported on MX Series routers starting with Junos OS Release 20.2R1.
`/mpls/signalling-protocols/ldp/p2mp-interfaces/p2mp-interface/state/counters/`	Sensor to export statistics for multipoint LDP egress traffic per interface. Supported on MX Series routers starting with Junos OS Release 20.2R1.
`/mpls/signalling-protocols/ldp/p2mp-egress-interfaces/p2mp-interface/state/counters/`	Sensor to export statistics for multipoint LDP egress traffic per interface. Supported only on MPC10E-10C-MRATE, MPC10E-15C-MRATE, and MX2K-MPC11E line cards line cards on MX Series routers starting with Junos OS Release 20.3R1.
`/mpls/signalling-protocols/ldp/p2mp-interfaces/p2mp-interface/`	Sensor to export statistics for multipoint LDP ingress traffic per interface. Supported on MX Series routers starting with Junos OS Release 20.2R1.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description

/mpls/lsps/signaling-protocols/rsvp-te/sessions/session[local-index='*foo-index*']/state/notify-status	Sensor to export statistics for ingress point-to-point LSPs, point-to-multipoint LSPs, bypass LSPs, and dynamically created LSPs.
	
	ON_CHANGE support for LSP events is only activated when the reporting interval is set to 0 in the subscription request.
	
	Supported on PTX Series routers, MX Series routers, and QFX10002, QFX10008, and QFX10016 switches starting with Junos OS Release 17.2R1.
	
	The following events are exported under this resource path:
	
	• PATHERR_RECEIVED
	  • TTL_EXPIRED
	  • NON_RSVP_CAPABLE_ROUTER
	  • RESVTEAR_RECEIVED
	  • PATH_MTU_CHANGE

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/network-instances/network-instance/mpls/signaling-protocols/rsvp-te/`	Sensor to export events for ingress point-to-point LSPs, point-to-multipoint LSPs, bypass LSPs, and dynamically created LSPs. Starting in Junos OS Evolved Release 19.2R1, PTX10003 routers support streaming statistics. The following end paths are also supported: • `interface-attributes/interface/bandwidth-reservations/state/active-reservations-count` • `interface-attributes/interface/bandwidth-reservations/state/available-bandwidth` • `interface-attributes/interface/bandwidth-reservations/state/highwater-mark` • `interface-attributes/interface/bandwidth-reservations/state/reserved-bandwidth` • `interface-attributes/interface/counters/in-ack-messages` • `interface-attributes/interface/counters/in-hello-messages` • `interface-attributes/interface/counters/in-path-messages` • `interface-attributes/interface/counters/in-path-tear-messages` • `interface-attributes/interface/counters/in-reservation-error-messages` • `interface-attributes/interface/counters/in-reservation-messages` • `interface-attributes/interface/counters/in-reservation-tear-messages` • `interface-attributes/interface/counters/in-srefresh-messages` • `interface-attributes/interface/counters/out-path-tear-messages` • `interface-attributes/interface/counters/out-ack-messages` • `interface-attributes/interface/counters/out-hello-messages`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• interface-attributes/interface/counters/out-path-messages • interface-attributes/interface/counters/out-reservation-error-messages • interface-attributes/interface/counters/out-reservation-messages • interface-attributes/interface/counters/out-reservation-tear-messages • interface-attributes/interface/counters/out-srefresh-messages • neighbors/neighbor/state/neighbor-status • sessions/session/record-route-objects/record-route-object • sessions/session/state/destination-address • sessions/session/state/label-in • sessions/session/state/label-out • sessions/session/state/lsp-id

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
`/mpls/signaling-protocols/segment-routing/`	Sensor for traffic statistics for both ingress IP traffic and transit MPLS traffic. Supported on MX Series and PTX Series routers starting with Junos OS Release 18.3R1. The following end points are also supported and specify BGP Segment Routing traffic Engineering (SR-TE) transit statistics: • `/sr-te-bsid-policies/sr-te-bsid-policy[binding-sid='80001', to-address='`*`foo-to`*`' color='`*`foo-color`*`']/state/counters[name='oc-`*`xxx`*`']/packets` • `/sr-te-bsid-policies/sr-te-bsid-policy[binding-sid='80001', to-address='`*`foo-to`*`' color='`*`foo-color`*`']/state/counters[name='oc-`*`xxx`*`']/bytes` The following end points are also supported and specify BGP Segment Routing traffic Engineering (SR-TE) ingress statistics: • `/sr-te-ip-policies/sr-te-ip-policy[to-address='`*`foo-to`*`' color='`*`foo-color`*`']/state/counters[name='oc-`*`xxx`*`']/packets` • `/sr-te-ip-policies/sr-te-ip-policy[to-address='`*`foo-to`*`' color='`*`foo-color`*`']/state/counters[name='oc-`*`xxx`*`']/bytes` In addition to configuring the sensor, you must enable statistics collection using the statistics statement at the [`[edit protocols` `https://www.juniper.net/documentation/us/en/software/junos/cli-reference/topics/ref/statement/source-packet-routing-edit-protocols.html` `telemetry statistics`] hierarchy level.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/system/linecard/packet/usage/	Sensor for Packet Forwarding Engine Statistics. This sensor exports statistics for counters and provides visibility into Packet Forwarding Engine error and drop statistics. This sensor is supported starting on MX Series and PTX Series routers starting with Junos OS Release 17.4R1. Starting in Junos OS Evolved Release 19.1R1, PTX10003 routers are supported. Starting in Junos OS Release 19.2R1, MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5200 switches are supported on gRPC and gNMI services. Starting with Junos OS Evolved Release 19.4R1, periodic streaming using gNMI services with PTX10003 routers is supported.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/junos/system/linecard/packet/usage/	Sensor for Packet Forwarding Engine Statistics. This sensor exports statistics and provides visibility into Packet Forwarding Engine error and drop statistics. Statistics include counters (CC, CPU, and NPU) for traffic data. Note that NPU statistics are different than those streamed from the sensors **/junos/system/linecard/npu/memory/** and **/junos/system/linecard/npu/utilization/** . Sensor output is comparable to the output using the operational mode command **show pfe statistics traffic**. The statistics that are shown below are exported for the default FPC (**FPC0**). Multiples FPCs are supported. The component values and property values are names (like interface names). Starting in Junos OS Evolved Release 19.4R1, streaming statistics using gRPC and gNMI services on PTX10008 routers is supported. Starting in Junos OS Release 20.2R1, INITIAL_SYNC statistics using gNMI services on MX960, MX2008, MX2010, MX2020, PTX1000, PTX5000 routers, PTX10000 line of routers, and QFX5100 and QFX5200 switches are supported. Starting in Junos OS Evolved Release 21.4R1, streaming statistics by means of gRPC and gNMI is supported on PTX10001-36MR, PTX10004, and PTX10008 routers. The following paths are also supported: • `:/components/component[name='FPC0:CC0']/properties/property[name='ts-input-packets']/` • `/components/component[name='FPC0:CC0']/properties/property[name='ts-output-packets']/` • `//components/component[name='FPC0:CC0']/properties/property[name='ts-input-packets-pps']/` • `/components/component[name='FPC0:CC0']/properties/property[name='ts-output-packets-pps']/` • `/components/component[name='FPC0:CC0']/properties/property[name='ts-fabric-input-packets']/`

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components/component[name='FPC0:CC0']/properties/property[name='ts-fabric-input-packets-pps']/ • /components/component[name='FPC0:CC0']/properties/property[name='ts-fabric-output-packets']/ • /components/component[name='FPC0:CC0']/properties/property[name='ts-fabric-output-packets-pps']/ • /components/component[name='FPC0:CPU0']/properties/property[name='lts-input-packets']/ • /components/component[name='FPC0:CPU0']/properties/property[name='lts-output-packets']/ • /components/component[name='FPC0:CPU0']/properties/property[name='lts-sw-input-control-drops']/ • /components/component[name='FPC0:CPU0']/properties/property[name='lts-sw-input-high-drops']/ • /components/component[name='FPC0:CPU0']/properties/property[name='lts-sw-input-medium-drops']/ • /components/component[name='FPC0:CPU0']/properties/property[name='lts-sw-input-low-drops']/ • /components/component[name='FPC0:CPU0']/properties/property[name='lts-sw-output-low-drops']/ • /components/component[name='FPC0:CPU0']/properties/property[name='lts-hw-input-drops']/ • /components/component[name='FPC0:NPU0']/properties/property[name='hwdsNormal']/ • /components/component[name='FPC0:NPU0']/properties/property[name='hwds-data-error']/ • /components/component[name='FPC0:NPU0']/properties/property[name='hwds-tcp-error']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• /components/component[name='FPC0:NPU0']/properties/property[name='hwds-illegal-nh']/ • /components/component[name='FPC0:NPU0']/properties/property[name='hwds-invalid-iif']/ //components/component[name='FPC0:NPU0']/properties/property[name='hwds-fabric']/

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description

/junos/system/linecard/packet-capture	Sensor for secure packet capture.
	
	Starting in Junos OS Release 21.2R1 on EX4400 switches, we support secure packet capture. You can use this feature to capture packets from a device and send them over a secure channel to an external collector (in the cloud) for monitoring and analysis. The maximum size of the packet you can capture is 128 bytes, including the packet header and the data within. Network professionals use real-time packet capture data to troubleshoot complex issues such as network and performance degradation and poor end-user experience.
	
	To use secure packet capture, include the */junos/system/linecard/packet-capture* resource path using a Junos RPC call.
	
	For ingress packet capture, include the packet-capture option in the existing firewall filter configuration at the
	
	`[edit firewall family family-name filter filter-name term match-term then packet-capture]`
	
	hierarchy level. Do this before you send packet capture sensor data to the collector and remove the packet-capture configuration after data is sent to the collector. After the capture is done, ingress packets with the filter match conditions are trapped to the CPU. The trapped packets then go to the collector over a secure channel in Junos Telemetry-specified format in key-value pairs by means of Remote Procedure Call (gRPC) transport.
	
	For egress packet capture on physical interfaces (ge-*, xe-*, mge-*, and et-*), include "packet-capture-telemetry," "egress," and "interface <interface-name>" at the `[edit forwarding-options]` hierarchy level. For example:
	
	`set forwarding-options packet-capture-telemetry egress interface ge-0/0/0`
	
	`set forwarding-options packet-capture-telemetry egress interface ge-0/0/10`
	
	You can add multiple interfaces on the device for egress packet capture. When configured, host-bound egress packets are captured

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	from the interface and sent to the collector. As with the ingress configuration, remove the configuration when packet capture is not required. **NOTE**: Starting in Junos OS Release 25.3R1 on EX2300,EX2300-MP,EX2300-C, and EX2300-VC switches, we support secure and dynamic packet capture.

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
/interfaces/	Sensor for device monitoring. To stream statistics, use the resource path **/interfaces/** in a subscription to export statistics to a collector in the following format: /interfaces/interface[name='et-*/*/*']/. Exported statistics include the following: • /interfaces/interface[name='et-*/*/*']/init_time • /interfaces/interface[name='et-*/*/*']/oper-status • /interfaces/interface[name='et-*/*/*']/parent_ae_name • /interfaces/interface[name='et-*/*/*']/in-pkts • /interfaces/interface[name='et-*/*/*']/in-octets • /interfaces/interface[name='et-*/*/*']/in-unicast-pkts • /interfaces/interface[name='et-*/*/*']/in-multicast-pkts • /interfaces/interface[name='et-*/*/*']/in-broadcast-pkts • /interfaces/interface[name='et-*/*/*']/in-pause-pkts • /interfaces/interface[name='et-*/*/*']/out-pkts • /interfaces/interface[name='et-*/*/*']/out-octets • /interfaces/interface[name='et-*/*/*']/out-unicast-pkts • /interfaces/interface[name='et-*/*/*']/out-multicast-pkts • /interfaces/interface[name='et-*/*/*']/out-broadcast-pkts • /interfaces/interface[name='et-*/*/*']/out-pause-pkts • /interfaces/interface[name='et-*/*/*']/in-errors • /interfaces/interface[name='et-*/*/*']/in-discards • /interfaces/interface[name='et-*/*/*']/out-errors

Table 28: gRPC Sensors *(Continued)*

Resource Path	Description
	• `/interfaces/interface[name='et-*/*/*']/out-discards` Supported starting in Junos OS 22.3R1 on PTX10003 routers.
`/qos/interfaces/interface/output/queues/queue/state/`	Sensor for CoS telemetry support. To stream statistics, use the resource path **/qos/interfaces/interface/output/queues/queue/state/** in a subscription to retrieve statistics from a router to a collector in the following format: `/qos/interfaces/interface[interface-id='xe-1/1/5:0']` . The following end points are supported: • `/queues/queue[name='0']/state/transmit-pkts` • `/queues/queue[name='0']/state/transmit-octets` • `/queues/queue[name='0']/state/dropped-pkts` Starting in Junos OS Evolved Release 21.4R1, streaming statistics by means of gRPC and gNMI is supported on PTX10001-36MR, PTX10003, PTX10004, PTX10008, and PTX10016 routers.
`/system/alarms/alarm`	INITIAL_SYNC support for OpenConfig data model openconfig-platform.yang and openconfig-alarms.yang. This feature lets the collector have a complete view of the current state of every sensor it is subscribed to. INITIAL_SYNC requires that at least one copy of all the sensors be sent to the collector. Starting in Junos OS Evolved Release 21.4R1, streaming statistics by means of gRPC and gNMI is supported on PTX10001-36MR, PTX10003, PTX10004, PTX10008, and PTX10016 routers.

Table 29: Broadband Edge gRPC Sensors

resource path	Description
`/junos/system/subscriber-management/chassis/virtual-chassis-ports/virtual-chassis-port` `/junos/system/subscriber-management/chassis/virtual-chassis-ports/virtual-chassis-port[vcp-interface-name=`*`vcp-interface-port-string`*`]` (to specify the interface name)	Virtual chassis port counter sensor. The sensor includes these statistics: • Input packets • Output packets • Input bytes • Output bytes Starting with Junos OS Release 20.2R1, streaming statistics from a virtual chassis is supported using gRPC services with MX480, MX960, MX10003, MX2010, and MX2020 routers.
`/junos/system/subscriber_management/dynamic-interfaces/interface-sets/meta-data/interface[sid-id='`*`sid-value`*`']/`	Sensor for subscriber interface information. ON-CHANGE streaming is supported. The following end paths are supported: • `interface-index`-The system assigned interface index for the interface. • `session-type`-The type of client session (e.g VLAN, DHCP, PPPoE). • `user-name`-The login name for this interface and session. • `profile-name`-The name of the client profile used to create the interface. • `underlying-interface-name`-The name of the associated underlying interface. • `cvlan-tag`-The innermost VLAN tag value associated with the interface. • `svlan-tag`-The outermost VLAN tag value associated with the interface.

Table 29: Broadband Edge gRPC Sensors *(Continued)*

resource path	Description
`/junos/system/subscriber_management/dynamic-interfaces/interface-sets/meta-data/interface[sid-id='sid-value']/`	Sensor for actual accounting statistics for dynamic subscriber interfaces. The following end paths are supported: • `ip-in-packets`-The number of actual transit IPv4 and IPv6 packets received by the interface. • `ip-out-packets`-The number of actual transit IPv4 and IPv6 packets sent to the interface. • `ip-in-bytes`-The number of actual transit IPv4 and IPv6 bytes received by the interface. • `ip-out-bytes`-The number of actual transit IPv4 and IPv6 bytes received by the interface. • `ipv6-in-packets`-The number of actual transit IPv6 packets received by the interface. • `ipv6-out-packets`-The number of actual transit IPv6 packets sent to the interface. • `ipv6-in-bytes`-The number of actual transit IPv6 bytes received by the interface. • `ipv6-out-bytes`-The number of actual transit IPv6 bytes sent to the interface.
`/junos/system/linecard/ddos/`	This PFE sensor exports the statistics of DDOS from MPC1, MPC2, MPC3, MPC5, MPC6, MPC7, MPC8, and MPC9 line cards.

Change History Table

Feature support is determined by the platform and release you are using. Use Feature Explorer to determine if a feature is supported on your platform.

Release	Description
20.1R1	Starting with Junos Release 20.1R1, gNMI service for streaming telemetry sensors for Packet Forwarding Engine statistics is supported on MX2K-MPC11E line cards on MX2010 and MX2020 routers.

19.4R1	Starting with Junos OS Release 19.4R1, gRPC service for streaming Packet Forwarding Engine and Routing Engine statistics is supported on EX4300-MP switches.
19.3R1	Starting with Junos OS Release 19.3R1, gNMI services for streaming Packet Forwarding Engine statistics is supported on MX240, MX480 and MX960 routers.
19.3R1	Starting with Junos OS Release 19.3R1, gRPC service for exporting statistics is supported on MX Series routers hosting MPC10E-10C-MRATE and MPC10E-15C-MRATE line cards. The resource paths **/junos/system/linecard/cpu/memory/**, **/junos/system/linecard/npu/memory/**, and **/junos/system/linecard/npu/utilization/** can be updated to call out individual sensors (leaves) and their respective paths for better clarity.
19.3R1	Starting with Junos OS Evolved Release 19.3R1, gRPC service for exporting statistics is supported on QFX5220-128C and QFX5220-32CD switches.
19.2R1	Starting with Junos OS Release 19.2R1, SRX4100, SRX4200, SRX4600, SRX5400, SRX5600, SRX5800, and vSRX Virtual Firewall Series Services Gateways.are supported.
19.2R1	Starting with Junos OS Release 19.2R1, gNMI services for streaming Packet Forwarding Engine statistics is supported on MX960, MX2008, MX2010 and MX2020 routers, PTX1000 and PTX10000 routers, and QFX5100 and QFX5200 switches.
19.2R1	Starting with Junos OS Release 19.2R1, gNMI services for streaming statistics is supported on QFX5110, QFX5120, QFX5200 and QFX5210 switches.
19.2R1	Starting with Junos OS Release 19.3R1, gNMI services for streaming and ON_CHANGE export of Routing Engine statistics is supported on MX960, MX2010, MX2020, PTX5000, PTX1000, and PTX10000 routers.
19.1R1 EVO	Starting in Junos OS Evolved Release 19.1R1, OpenConfig (OC) and Junos Telemetry are supported. Both gRPC APIs and the customer-facing CLI remain the same as for the Junos OS. As was standard for Junos OS, Network Agent (NA) and OC packages are part of the Junos OS Evolved image.
19.1R1	Starting with Junos OS Evolved 19.1R1, Packet Forwarding Engine sensors on PTX10003 routers are also supported.
18.4R1	Starting with Junos OS Release 18.4R1, MX480, MX960, MX2010, MX2020, MX2008 and MX-ELM routers are also supported.

18.4R1	Starting with Junos OS Release 18.4R1, BGP operational states are aligned and compliant with OpenConfig data model **openconfig-bgp-operational.yang**. To stream BGP operational states, use the resource path **/network-instances/network-instance/protocols/protocol/bgp/**. Previously, the path was **/bgp/**.
18.3R1	Starting with Junos OS Release 18.3R1, ON_CHANGE streaming of LLDP telemetry sensor information is supported through gRPC for MX Series and PTX Series routers.
18.3R1	Starting with Junos OS Release 18.3R1, QFX5120-48Y and EX4650 switches are also supported.
18.3R1	Starting with Junos OS Release 18.4R1, EX4600 switches are also supported.
18.2R1	Starting with Junos OS Release 18.2R1, PTX10002 routers are also supported.
18.1R1	Starting with Junos OS Release 18.1R1, QFX5210-64C switches and QFX5100 switches are also supported.
18.1R1	Starting with Junos OS Release 18.1R1, ON_CHANGE streaming of ARP, ND, and IP sensor information associated with interfaces is supported through gRPC for MX Series routers and PTX Series routers.
17.4R1	Starting with Junos OS Release 17.4R1, PTX10016 routers and virtual MX Series (vMX) routers are also supported.
17.3R1	Starting with Junos OS Release 17.3R1, QFX5110 switches, EX4600, EX4600-VC, and EX9200 switches and the Routing and Control Board (RCB) on PTX3000 routers are also supported.
17.3R1	Starting with Junos OS Release 17.3R1, broadband edge (BBE) gRPC sensors are supported.
17.3R1	In Junos OS Release 17.3R1, broadband edge (BBE) gRPC sensor `/junos/system/subscriber-management/client-protocols/dhcp/v4/routing-instances/routing-instance[ri-name='`*routing-instance-name*`'] /server/statistics/` the only value supported for *routing-instance-name* is `default`.
17.3R1	In Junos OS Release 17.3R1, broadband edge (BBE) gRPC sensor `/junos/system/subscriber-management/client-ancpinstance[ri-name='`*routing-instance-name*`'] /server/statistics/` the only value supported for *routing-instance-name* is `default`.
17.3R1	In Junos OS Release 17.3R1, broadband edge (BBE) gRPC sensor `/junos/system/subscriber-management/client-protocols/dhcp/v4/routing-instances/routing-instance[ri-name='`*routing-instance-name*`']/relay/statistics/` the only value supported for the value *routing-instance-name* is `default`.

17.3R1	In Junos OS Release 17.3R1, broadband edge (BBE) gRPC sensor `/junos/system/subscriber-management/client-protocols/dhcp/v6/ routing-instances/routing-instance[ri-name=’` *`routing-instance-name`*`’]/server/statistics` the only value supported for *routing-instance-name* is `default`.
17.3R1	In Junos OS Release 17.3R1, broadband edge (BBE) gRPC sensor `/junos/system/subscriber-management/client-protocols/dhcp/v6/ routing-instances/routing-instance[ri-name=’` *`routing-instance-name`*`’]/relay/statistics` the only value supported for *routing-instance-name* is `default`.
17.2R1	Starting with JunosOS Release 17.2R1, QFX10002, QFX10008, and QFX10016 switches, QFX5200 switches, and PTX1000 and PTX10008 routers are also supported.
16.1R3	Starting with Junos OS Release 16.1R3, the Junos Telemetry supports gRPC remote procedure calls (gRPC) to provision sensors and to subscribe to and receive telemetry data on MX Series routers and PTX3000 and PTX5000 routers.

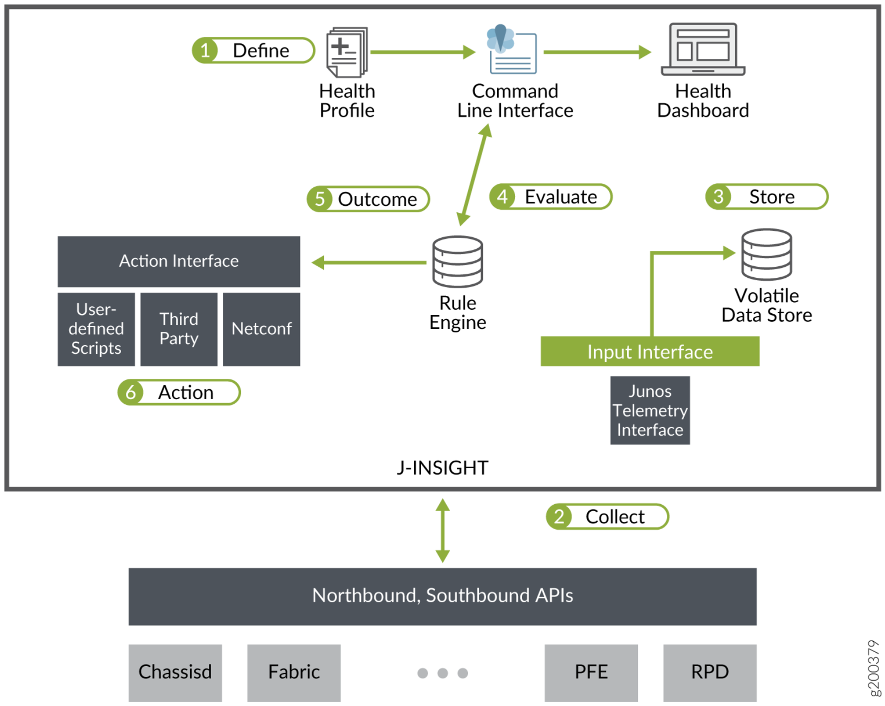
J-Insight Device Monitor Overview

IN THIS SECTION

As networks become increasingly complex, the need to adopt features that simplify the process of monitoring, maintaining, and improving the overall health of your networking devices becomes increasingly critical to delivering services in a more predictable and manageable way.

J-Insight is a data-driven device monitoring solution that provides visibility and insight into the health of a running system. Starting with Junos OS Release 18.2R1, the J-Insight framework facilitates real-time monitoring of system resources for FPC FRUs. It also has been integrated with the existing connectivity error management infrastructure to normalize error detection, monitoring, and reporting. The long-term goal for the architectural design of the J-Insight device monitor is depicted in Figure 10 on page 341.

Figure 10: Long-term High-level Architecture for J-Insight



J-Insight is an on-premise system application that uses the Junos Telemetry Interface to continuously collect data that is reflective of the current state and health of the device component being monitored.

Understanding How J-Insight Health Monitoring Works

As part of this initial release, the J-Insight health monitor supports the following process flow (see Figure 10 on page 341):

1. Consumes a pre-defined static health profile. The health profile is not user-configurable through the Junos OS CLI.

2. Using the Junos Telemetry framework, subscribes to health KPIs specified in the default health profile. J-Insight health monitor subscribes to Junos Telemetry sensors using a standard interface. Health monitor subscription and reporting is disabled, by default, and can be enabled through the Junos OS CLI. Starting with Junos OS Release 18.2R1, the following health KPIs are supported for MX-based FPCs:

   - CPU utilization

   - Temperature sensors

- PFE memory utilization
- Fabric reachability

3. Collates the Junos Telemetry data streams collected from various sub-systems.

4. Evaluates the health data against configured thresholds and reports the health status.

Understanding How J-Insight Fault Monitoring Works

Starting with Junos OS Release 18.2R1, J-Insight utilizes the connectivity error management infrastructure to normalize error detection, monitoring, and reporting. Through this infrastructure, J-Insight also provides the capability to define data-driven fault policies. Each module can define error properties by reading a DST/capability file. The fault monitoring capability is available by default in Junos OS and cannot be enabled or disabled through the CLI.

Each error is defined by the following properties:

- **URI**—Error identifier. Each error is uniquely identified with an error ID that is represented as a Uniform Resource Identifier (URI).
- **Error**—Error name.
- **Scope**—Error scope. An error scope provides a level of classification above the error category. Examples of error scope values include: pfe and board.
- **Category**—Error category. An error category categories errors into various subgroups under a specific error scope level. Examples of error category values include: memory, processing, and storage.
- **Details**—Description for the error.
- **Count**—The number of times error instances have occurred.
- **Clear count**—The number of times error instances have been cleared.
- **Support**—Support details for the error type.

RELATED DOCUMENTATION

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J-Insight Device Monitor Basic Configuration

IN THIS SECTION

Before you Begin

NOTE: If you're running Junos OS Evolved software, you do not need to perform the procedures in this "Before you Begin" section.

J-Insight requires that your Junos OS device supports the Junos Telemetry. To use J-Insight, you must first complete the following steps:

1. Use the `show agent sensors` command to verify whether or not J-Insight has successfully subscribed to sensors on which it is dependent.

```
user@host> show agent sensors
.
.
.
Sensor Information :

    Name                                    : sensor_1000
    Resource                                : /junos/events/event[id='CHASSISD_SNMP_TRAP7']/
    Version                                 : 1.0
    Sensor-id                               : 539528115
    Subscription-ID                         : 1000
    Parent-Sensor-Name                      : Not applicable
    Component(s)                            : eventd

    Profile Information :
```

```
        Name                                : export_1000
        Reporting-interval                  : 0
        Payload-size                        : 5000
        Format                              : GPB

Sensor Information :

    Name                                    : sensor_1001
    Resource                                : /junos/system/cmerror/configuration/
    Version                                 : 1.0
    Sensor-id                               : 539528114
    Subscription-ID                         : 1001
    Parent-Sensor-Name                      : Not applicable
    Component(s)                            : PFE

    Profile Information :

        Name                                : export_1001
        Reporting-interval                  : 6
        Payload-size                        : 5000
        Format                              : GPB

Sensor Information :

    Name                                    : sensor_1002
    Resource                                : /junos/system/cmerror/counters/
    Version                                 : 1.0
    Sensor-id                               : 539528113
    Subscription-ID                         : 1002
    Parent-Sensor-Name                      : Not applicable
    Component(s)                            : PFE

    Profile Information :

        Name                                : export_1002
        Reporting-interval                  : 6
        Payload-size                        : 5000
        Format                              : GPB

Sensor Information :

    Name                                    : sensor_1003
    Resource                                : /components/
```

```
    Version                                   : 1.0
    Sensor-id                                 : 539528112
    Subscription-ID                           : 1003
    Parent-Sensor-Name                        : Not applicable
    Component(s)                              : chassisd

    Profile Information :

        Name                                  : export_1003
        Reporting-interval                    : 6
        Payload-size                          : 5000
        Format                                : GPB

Sensor Information :

    Name                                      : sensor_1004
    Resource                                  : /junos/services/health-monitor/config/
    Version                                   : 1.0
    Sensor-id                                 : 539528119
    Subscription-ID                           : 1004
    Parent-Sensor-Name                        : Not applicable
    Component(s)                              : PFE

    Profile Information :

        Name                                  : export_1004
        Reporting-interval                    : 7
        Payload-size                          : 5000
        Format                                : GPB

Sensor Information :

    Name                                      : sensor_1005
    Resource                                  : /junos/services/health-monitor/data/
    Version                                   : 1.0
    Sensor-id                                 : 539528118
    Subscription-ID                           : 1005
    Parent-Sensor-Name                        : Not applicable
    Component(s)                              : PFE

    Profile Information :

        Name                                  : export_1005
```

```
        Reporting-interval                 : 7
        Payload-size                       : 5000
        Format                             : GPB
```

J-Insight Health Monitoring

- To enable the J-Insight health monitor:

```
user@host# set services jinsightd subscribe health-monitor
```

- To disable the J-Insight health monitor:

```
user@host# delete services jinsightd subscribe health-monitor
```

- To display the J-Insight health monitor results:

```
user@host> show system health-monitor [fpc fpc-slot slot-number]
```

J-Insight Fault Monitoring

IN THIS SECTION

Starting with Junos OS Evolved Release 19.1R1, J-Insight fault monitoring support is added for CB, chassis, fan, FPC, FPM, PDU, PIC, PSM, RE and SIB FRUs.

Chassis-level Configuration Commands

The Junos OS resiliency feature provides debugging capabilities in the case of device component failure. You can configure Packet Forwarding Engine (PFE)-related error levels on FRUs such as FPCs. Using the *error* configuration statement, you can set an automatic recovery action for each severity and configure the actions to perform when a specified threshold is reached.

For more information, see the Chassis-Level User Guide.

Trace Commands

- (Junos OS only) To enable J-Insight trace options for debugging:

```
user@host# set services jinsightd traceoptions flag trace-option
```

- (Junos OS Evolved only) You can view collected J-Insight traces with the **show trace application jinsightd** command, and remove inactive J-Insight tracing sessions with the **clear trace application jinsightd** command.

Clear & Show Commands

- To clear all system errors or a specific error denoted by the error ID Uniform Resource Identifier (URI) for a specific FPC:

```
user@host> clear chassis fpc errors fpc-slot  slot-number [ all |  error-id error-id- uri]
```

- To display information on alarms that have been triggered by faults:

```
user@host> show chassis alarms
```

- To display summary or detailed information about the active errors based on FRU, error scope, or error category:

```
user@host> show system errors active  [[fru slot-number] | [detail [fru slot-number [scope
error-scope ] [category error-category ]]]
```

- To display a summary of the number of detected errors and recovery actions taken based on severity level:

```
user@host> show system errors count
```

- To display information about a detected error based on its error ID URI:

```
user@host> show system errors error-id error-id-uri
```

- To display detailed information about the detected errors based on the FRU:

```
user@host> show system errors fru detail [fru slot-number]
```

RELATED DOCUMENTATION

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