Telemetry Configuration Guide for Cisco NCS 4000 Series Routers, IOS XR Release 6.5.x

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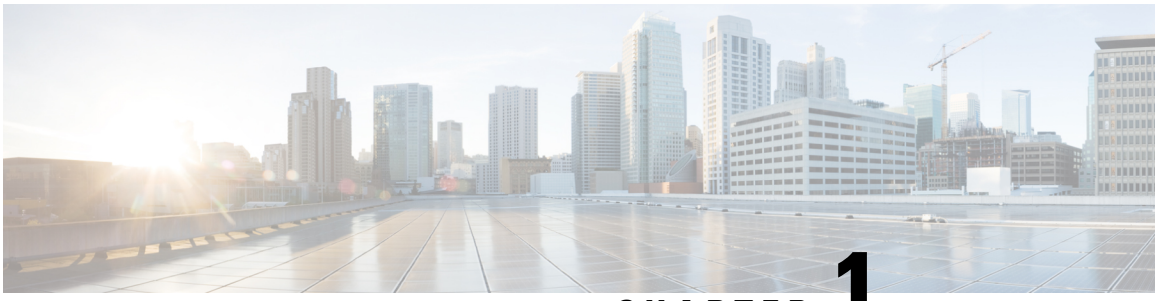


CHAPTER 1

Scale-Up Your Network Monitoring Strategy Using Telemetry

Table 1: Feature History

Feature Name	Release Information	Feature Description
Telemetry	Cisco IOS XR Release 6.5.31	The traditional methods of monitoring your network such as SNMP, Syslog, and CLI use a pull model to request information at regular intervals. The data that you collect may help you to efficiently monitor your network of a manageable size. However, as your network grows in complexity and scale, the data that you poll may be insufficient for efficient and effective monitoring. Telemetry uses a push model that automatically streams data from a server. Instead of a client requesting data at periodic intervals, the server streams operational data in real time. Telemetry focuses on the power of scale, speed, and automation.

Are you monitoring your network using traditional polling methods such as SNMP, Syslog, and CLI? If yes, does the data that you extract from your network help you answer these questions?

- What percentage of the network bandwidth does the network traffic currently consume?
- Do all the links in the network run at a hundred percent utilization rate?
- If an unmanned router fails, is the network operator notified in real time about the issue and its related consequences?
- Is the CPU over- or under-utilized?

- Can the efficiency of the network be calculated based on traffic and data loss?
- What are the possible performance issues that cause traffic loss or network latency?
- How do you proactively prevent issues that may arise? Does the data support the study of network patterns in real time?

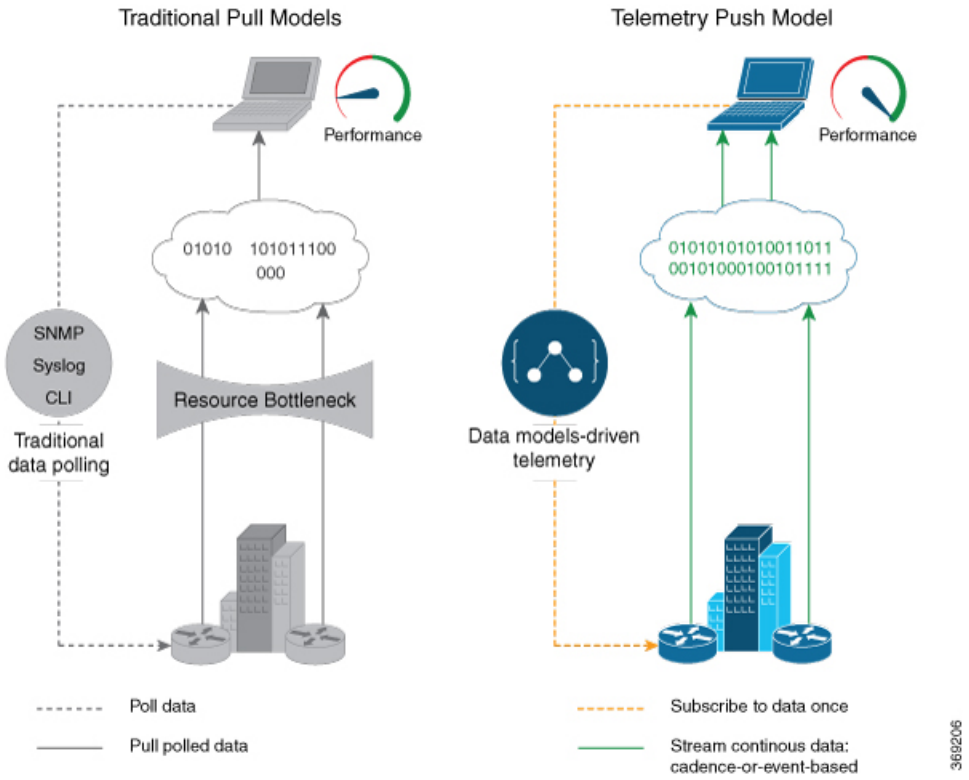
These traditional methods use a *pull* model to request information at regular intervals. The data that you collect may help you to efficiently monitor your network of a manageable size. However, as your network grows in complexity and scale, the data that you poll may be insufficient for efficient and effective monitoring. Additionally, the polling methods are resource-intensive, and network operators face information gaps in the data that they collect. With the pull model, the network device (the server) sends data only when the data collector (the client) requests it. Initiating such requests requires continual manual intervention. This manual intervention makes this model unsuitable, and limits automation and the ability to scale. It inhibits the visibility of the network and therefore provides inefficient control of the network. You need monitoring strategy that adds resiliency and stability to your network.

Telemetry does just that. Telemetry uses a *push* model that automatically streams data from a network device. Instead of a collector requesting data at periodic intervals, the network device streams operational data in real time.

Telemetry focuses on the power of scale, speed, and automation. With the power of flexibility, you can select data of interest from the routers and transmit it in a structured format to remote management stations for monitoring. Using the finer granularity and higher frequency of data available through telemetry, DevOps (development and operations) engineers in your organization can quickly locate and investigate issues as soon as they occur. They can, thus, collaborate to monitor and have better control over the network.

The following image shows the comparative benefits of streaming telemetry data using the telemetry push model over traditional pull models. The pull models create resource bottlenecks that prevent retrieving valuable operational data from the router. On the other hand, the push model is designed to remove such bottlenecks and deliver data efficiently.

Figure 1: Comparison Between Traditional Pull Models and Telemetry Push Model



This article describes the benefits of using telemetry data and the various methods to stream meaningful data from your network device:

Benefits of Shifting Network Monitoring from Pull Models to Telemetry Push Model

Real-time telemetry data is useful in:

- **Managing network remotely:** The primary benefit of telemetry is the ability it offers you as an end user to monitor the state of a network element remotely. After the network is deployed, you cannot be physically present at the network site to find out what works, and what is cumbersome. With telemetry, those insights can be analyzed, leveraged, and acted upon from a remote location.
- **Optimizing traffic:** When link utilization and packet drops in a network are monitored at frequent intervals, it is easier to add or remove links, re-direct traffic, modify policing, and so on. With technologies like fast reroute, the network can switch to a new path and re-route faster than the traditional SNMP poll interval mechanism. Streaming telemetry data helps in providing quick response time for faster transport of traffic.

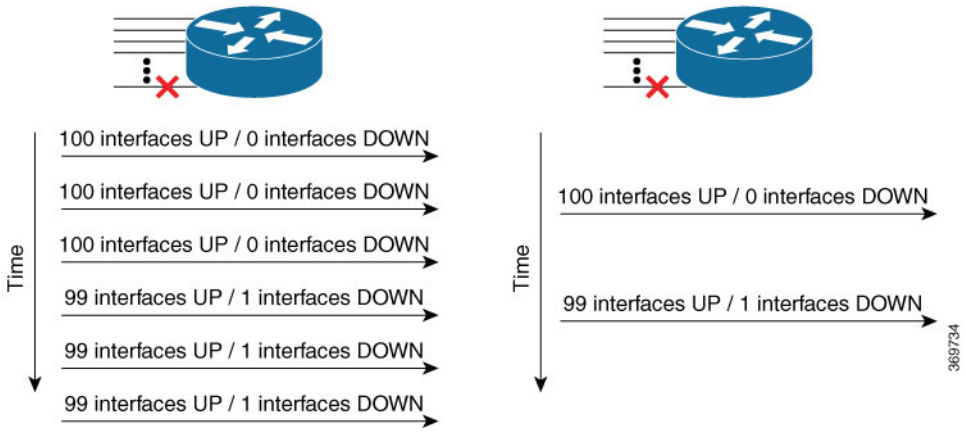
- **Preventive troubleshooting:** Network state indicators, network statistics, and critical infrastructure information are exposed to the application layer, where they are used to enhance operational performance and to reduce troubleshooting time. The finer granularity and higher frequency of data available through telemetry enables better performance monitoring and therefore, better troubleshooting.
- **Visualizing data:** Telemetry data acts as a data lake that analytics toolchains and applications use to visualize valuable insights into your network deployments.
- **Monitoring and controlling distributed devices:** The monitoring function is decoupled from the storage and analysis functions. This decoupling helps to reduce device dependency, while providing flexibility to transform data using pipelines. These pipelines are utilities that consume telemetry data, transform it, and forward the resulting content to a downstream, typically off-the-shelf, consumer. The supported downstream consumers include Apache Kafka, Influxdata, Prometheus, and Grafana.

Streaming telemetry, thus, converts the monitoring process into a Big Data proposition that enables the rapid extraction and analysis of massive data sets to improve decision-making.

Review Mechanisms to Stream Telemetry Data from a Router to a Destination

Telemetry data can be streamed using either cadence-driven or event-driven mechanisms.

Figure 2: Cadence-driven and Event-driven Telemetry

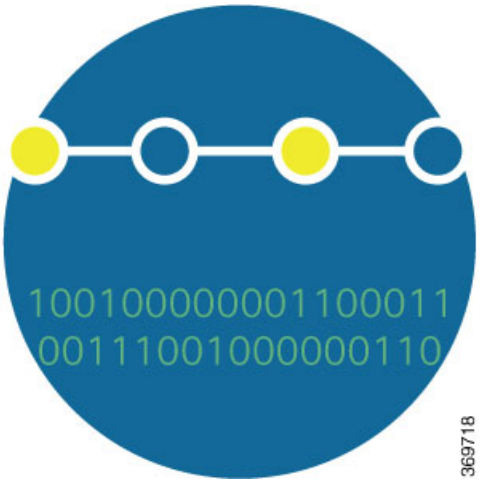


Cadence-driven Telemetry

Cadence-driven telemetry continually streams data (operational statistics and state transitions) at a configured cadence. The higher frequency of the data that is continuously streamed helps you closely identify emerging patterns in the network.

The following image shows a continuous stream of data after a configured time interval:

Figure 3: Cadence-driven Telemetry

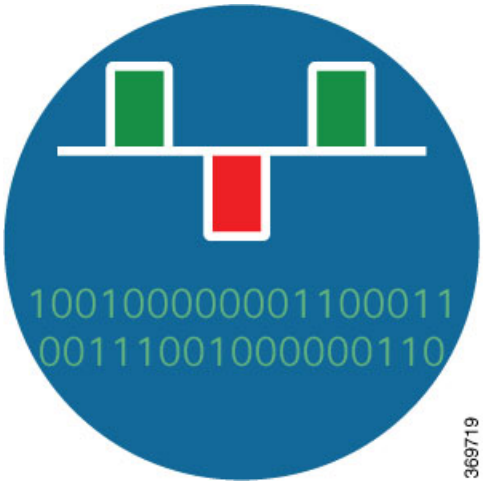


Event-driven Telemetry

Event-driven telemetry optimizes data that is collected at the receiver and streams data only when a state transition occurs and thus optimizes data that is collected at the receiver. For example, EDT streams data about interface state transitions, IP route updates, and so on.

The following image shows a stream of data after a state change:

Figure 4: Event-driven Telemetry



Learn About the Elements that Enable Streaming Telemetry Data

These elements are the building blocks in enabling telemetry in a network.

Sensor Path

The sensor path describes a YANG path or a subset of data definitions in a YANG data model with a container. In a YANG model, the sensor path can be specified to end at any level in the container hierarchy.

A YANG module defines a data model through the data of the router, and the hierarchical organization and constraints on that data.

YANG defines four node types. Each node has a name. Depending on the node type, the node either defines a value or contains a set of child nodes. The nodes types for data modeling are:

- leaf node - contains a single value of a specific type
- leaf-list node - contains a sequence of leaf nodes
- list node - contains a sequence of leaf-list entries, each of which is uniquely identified by one or more key leaves
- container node - contains a grouping of related nodes that have only child nodes, which can be any of the four node types

For more information about data models, see the *Programmability Configuration Guide for Cisco NCS 4000 Series Routers*.

The following table shows few examples of sensor paths. For the complete list of supported sensor paths, see Supported Sensor Paths, on page 21.

Table 2: Sensor Paths

Feature	Sensor Path
CPU	`Cisco-IOS-XR-wdsysmon-fd-oper:system-monitoring/cpu-utilization`
Memory	`Cisco-IOS-XR-nto-misc-oper:memory-summary/nodes/node/summary`

Interface	`Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/latest/generic-counters`
	`Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/data-rate`
	`openconfig-interfaces:interfaces/interface`

Optical power levels	`Cisco-IOS-XR-dwdm-ui-oper:dwdm/ports/port/info/optics-info`
Node summary	`Cisco-IOS-XR-nto-misc-oper:memory-summary/nodes/node/summary`
Forwarding information base (FIB)	`Cisco-IOS-XR-fib-common-oper:fib-statistics/nodes/node/drops` `Cisco-IOS-XR-fib-common-oper:fib/nodes/node/protocols/protocol/vrfs/vrf/summary`

MPLS Traffic engineering (MPLS-TE)	`Cisco-IOS-XR-mpls-te-oper:mpls-te/tunnels/summary`
	`Cisco-IOS-XR-ip-rsvp-oper:rsvp/interface-briefs/interface-brief`
	`Cisco-IOS-XR-mpls-te-oper:mpls-te/fast-reroute/protections/protection`
	`Cisco-IOS-XR-mpls-te-oper:mpls-te/signalling-counters/signalling-summary`
	`Cisco-IOS-XR-mpls-te-oper:mpls-te/p2p-p2mp-tunnel/tunnel-heads/tunnel-head`

Feature	Sensor Path

MPLS Label distribution protocol (MPLS-LDP)	`Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/nodes/node/bindings-summary-all`
	`Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/global/active/default-vrf/summary`
	`Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/nodes/node/default-vrf/neighbors/neighbor`

Routing	`Cisco-IOS-XR-clns-isis-oper:isis/instances/instance/statistics-global`
	`Cisco-IOS-XR-clns-isis-oper:isis/instances/instance/neighbors/neighbor`
	`Cisco-IOS-XR-ip-rib-ipv4-oper:rib/rib-table-ids/rib-table-id/summary-protos/summary-proto`
	`Cisco-IOS-XR-clns-isis-oper:isis/instances/instance/levels/level/adjacencies/adjacency`
	`Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/process-info`
	`Cisco-IOS-XR-ip-rib-ipv6-oper:ipv6-rib/rib-table-ids/rib-table-id/summary-protos/summary-proto`

Note Use specific paths to avoid streaming data that you may not be interested. For example, if you want to stream information about only the summary of MPLS-TE, use `sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/autotunnel/mesh/summary` instead of `sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te` sensor path.

The router streams telemetry data at predefined gather points in the data model even if sensor-path configuration is to an individual leaf. The gather points are collection units; collection always happens at that level for operational data.

The router supports the following sensor-path resolutions:

- Streaming data at the leaf-level or at the container-level under a gather point for cadence-based subscriptions.

  If a subscritpion has multiple sensor-paths that resolve to the same gather point and have the same cadence and encoding, data is pushed in a single collection stream for all the leaves. For example:

```
telemetry model-driven
destination-group tftp_server
  address-family ipv4 209.165.201.1 port 1234
   encoding json
   protocol tcp
  !
!
sensor-group Group1
  sensor-path Cisco-IOS-XR-ip-rsvp-oper:rsvp/nsr/status
!
subscription sub1
  sensor-group-id Group1 sample-interval 6000
  destination-id tftp_server
!
!
```

- For event-driven subscriptions, streaming is always at the gather point in the model, even if specific leaves or leaf is configured as sensor-path. There is configuration to restrict streaming specific leaves for event-driven subscriptions. If this configuration is used, the sensor-path of the configured leaf streams data even if there is a change in one of its adjacent leaves. This indicates that even if there is no change

in value of the configured leaf, data can stream out to the collector. The collector must be set to check if the leaf value changed before taking action on the streamed data.

```
telemetry model-driven
include select-leaves-on-events
```

Note It is not recommended to configure sensor-paths with the same gather point into different subscriptions.

An MDT-capable device, such as a router, associates the sensor path to the nearest container path in the model. The router encodes and streams the container path within a single telemetry message. A receiver receives data about all the containers and leaf nodes at and below this container path. The router streams telemetry data, for one or more sensor-paths, at the configured frequency (Cadence-driven Telemetry, on page 4), or when an event occurs (Event-driven Telemetry, on page 5), to one or more collectors through subscribed sessions.

Subscription

A subscription binds one or more sensor paths and destinations.

The collector uses the subscription to receive updates about the state of data on the router. A subscription can consist of one or more sensor paths. The data for the paths that you have subscribed starts streaming until the session is terminated by the collector or the telemetry subscription configuration is removed to cancel the subscription.

Encoder

Data that is streamed from a router can be encoded using one of these formats:

- **GPB encoding:** Configuring for GPB encoding requires metadata in the form of compiled `.proto` files. A `.proto` file describes the GPB message format which is used to stream data. The `.proto` files are available at Cisco Network Telemetry Proto in Github.
- **Self-describing GPB encoding:** Data streamed for each sensor path is in a self-describing and ASCII text format. A single `.proto` file, `telemetry.proto`, is used by the collector to decode any sensor path data. Self-describing GPB encoding is easier to manage because it needs single `.proto` file to decode any sensor path data, even though the message size is large.
- **JSON encoding:** Data is streamed in strings of keys and its values in a human-readable format.

Transport

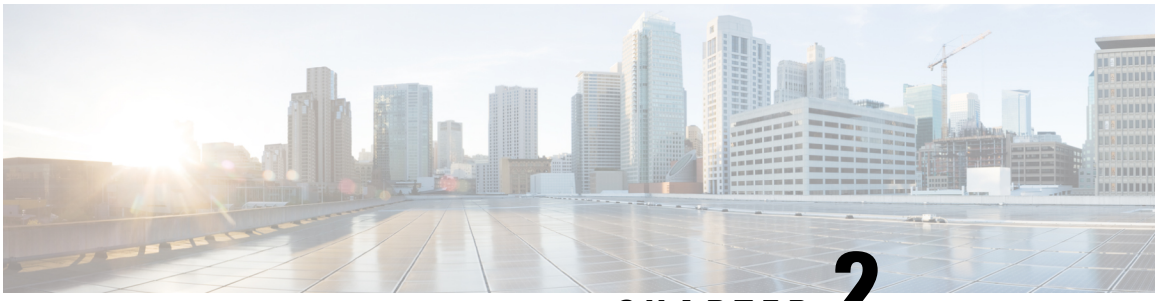
In the telemetry push model, the router streams telemetry data using a transport protocol. The generated data is encapsulated into the desired format using encoders.

Model-Driven Telemetry (MDT) data is streamed through Transmission Control Protocol (TCP) that is used only for dial-out mode.

Dial-Out Mode

In a *dial-out* mode, the router dials out to the receiver to establish a subscription-based telemetry session. Because the router initiates the connection, there is no need to manage the ports for inbound traffic. In this default mode of operation, the protocol you use to establish a session is TCP. A simple protocol requires only accessibility to the socket on the collector. A secure protocol, additionally, offers security capabilities to authenticate and encrypt the session. You can, therefore, secure your collector, and establish a much advanced method of communication with the router. If the connection between the router and the destination is lost, the router re-establishes the connection with the destination and continues to push data again. However, data transmitted during the time of reconnection is lost.

To explore the dial-out mode, and to create a dial-out session, see Establish a Model-Driven Telemetry Session from a Router to a Collector, on page 11.



CHAPTER 2

Establish a Model-Driven Telemetry Session from a Router to a Collector

Streaming telemetry is a new paradigm in monitoring the health of a network. It provides a mechanism to efficiently stream configuration and operational data of interest from Cisco IOS XR routers. This streamed data is transmitted in a structured format to remote management stations for monitoring and troubleshooting purposes.

With telemetry data, you create a data lake. Analyzing this data, you proactively monitor your network, monitor utilization of CPU and memory, identify patterns, troubleshoot your network in a predictive manner, and devise strategies to create a resilient network using automation.

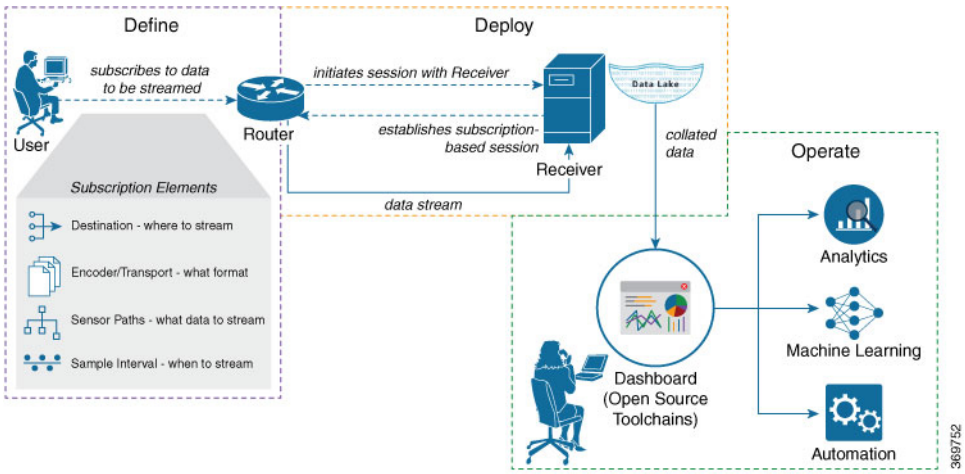
Telemetry works on a Subscription, on page 8 model where you subscribe to the data of interest in the form of Sensor Path, on page 6. The sensor paths describe native Cisco data models. You can access the Native data models for telemetry from Github, a software development platform that provides hosting services for version control. You choose who initiates the subscription by establishing a telemetry session between the router and the receiver. The session is established using a Dial-Out Mode, on page 9.

Note Watch this video to discover the power of real-time network management using model-driven telemetry.

This article describes the dial-out mode where the router dials out to the receiver to establish a telemetry session. In this mode, destinations and sensor-paths are configured and bound together into one or more subscriptions. The router continually attempts to establish a session with each destination in the subscription, and streams data to the receiver. The dial-out mode of subscriptions is persistent. Even when a session terminates, the router continually attempts to re-establish a new session with the receiver at regular intervals.

The following image shows a high-level overview of the dial-out mode:

Figure 5: Dial-Out Mode



This article describes, with a use case that illustrates the monitoring of CPU utilization, how streaming telemetry data helps you gain better visibility of your network, and make informed decisions to stabilize your network.

• Monitor CPU Utilization Using Telemetry Data to Plan Network Infrastructure, on page 12

Monitor CPU Utilization Using Telemetry Data to Plan Network Infrastructure

The use case illustrates how, with the Dial-Out Mode, on page 9, you can use telemetry data to proactively monitor CPU utilization. Monitoring CPU utilization ensures efficient storage capabilities in your network. This use case describes the tools used in the open-sourced collection stack to store and analyse telemetry data.

Note Watch this video to see how you configure model-driven telemetry to take advantage of data models, open source collectors, encodings and integrate into monitoring tools.

Telemetry involves the following workflow:

- **Define:** You define a subscription to stream data from the router to the receiver. To define a subscription, you create a destination-group and a sensor-group.
- **Deploy:** The router establishes a subscription-based telemetry session and streams data to the receiver. You verify subscription deployment on the router.
- **Operate:** You consume and analyse telemetry data using open-source tools, and take necessary actions based on the analysis.

Before you begin

Make sure you have L3 connectivity between the router and the receiver.

Define a Subscription to Stream Data from Router to Receiver

Create a subscription to define the data of interest to be streamed from the router to the destination.

Step 1 Create one or more destinations to collect telemetry data from a router. Define a destination-group to contain the details about the destinations. Include the destination address (ipv4 or ipv6), or FQDN, port, transport, and encoding format in the destination-group.

Example:

Create a destination-group using data model

This example uses the native data model `Cisco-IOS-XR-um-telemetry-model-driven-cfg.yang`.

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="101">
  <get-config>
    <source>
      <candidate/>
    </source>
    <filter>
      <telemetry-model-driven
xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-um-telemetry-model-driven-cfg">
        <destination-groups>
          <destination-group>
            <destination-id>CPU-Health</destination-id>
            <ipv4-destinations>
              <ipv4-destination>
                <ipv4-address>209.165.201.1</ipv4-address>
                <destination-port>4321</destination-port>
                <encoding>json</encoding>
                <protocol>
                  <protocol>tcp</protocol>
                </protocol>
              </ipv4-destination>
            </ipv4-destinations>
          </destination-group>
        </destination-groups>
      </telemetry-model-driven>
    </filter>
  </get-config>
</rpc>
```

Create a destination group using CLI

```
RP/0/RP1:SIT#configure
Sun Sep  6 19:32:59.258 IST
RP/0/RP1:SIT(config)#telemetry model-driven
RP/0/RP1:SIT(config-model-driven)#des
describe  destination-group
RP/0/RP1:SIT(config-model-driven)#destination-group CPU-Health
RP/0/RP1:SIT(config-model-driven-dest)#address-family ipv4 209.165.201.1 port 4321
RP/0/RP1:SIT(config-model-driven-dest-addr)#en
encoding  end
RP/0/RP1:SIT(config-model-driven-dest-addr)#encoding json
RP/0/RP1:SIT(config-model-driven-dest-addr)#protocol tcp
RP/0/RP1:SIT(config-model-driven-dest-addr)#commit
Sun Sep  6 19:34:08.748 IST
RP/0/RP1:SIT(config-model-driven-dest-addr)#end
```

where -

- `CPU-Health` is the name of the destination-group
- `209.165.201.1` is the IP address of the destination where data is to be streamed

  Note To avoid hard-coding IP address, the router can chose any of the configured ipv4 or ipv6 address using domain name service. If an established connections fails, the router connects to another resolved IP address, and streams data to that IP address.

- `4321` is the port number of the destination
- `json` is the format in which data is encoded and streamed to the destination
- `tcp` is the protocol through which data is transported to the destination.

The destination for dial-out configuration supports IP address (Ipv4 or IPv6), and fully qualified domain name (FQDN) using domain name services (DNS). To use FQDN, you must assign IP address to the domain name.The domain name is limited to 128 characters. If DNS lookup fails for the provided domain name, the internal timer is activated for 30 sec. With this, the connectivity is continually tried every 30 sec until the domain named is looked-up successfully. DNS provides an address list depending on the address-family being requested. For example, on the router, the IP address for domain name is set using the following commands for ipv4 and ipv6 respectively:

```
domain ipv4 host abcd 172.x.x.1 172.x.x.2
```

```
domain ipv6 host abcd fd00:xx:xx:xx:1::1 fd00:xx:xx:xx:1::3
```

Step 2 Specify the subset of the data that you want to stream from the router using sensor paths. The Sensor Path, on page 6 represents the path in the hierarchy of a YANG data model. Create a sensor-group to contain the sensor paths.

Example:

Create a sensor-group for CPU utilization using data model

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="101">
  <edit-config>
    <target>
      <candidate/>
    </target>
    <config>
      <telemetry-model-driven
xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-um-telemetry-model-driven-cfg">
        <sensor-groups>
          <sensor-group>
            <sensor-group-identifier>CPU-MONITORING</sensor-group-identifier>
            <sensor-paths>
              <sensor-path>

<telemetry-sensor-path>Cisco-IOS-XR-wdsysmon-fd-oper:system-monitoring</telemetry-sensor-path>
              </sensor-path>
            </sensor-paths>
          </sensor-group>
        </sensor-groups>
      </telemetry-model-driven>
    </config>
  </edit-config>
</rpc>
```

Create a sensor-group for CPU utilization using CLI

```
RP/0/RP1:SIT#configure
Sun Sep  6 19:37:17.898 IST
RP/0/RP1:SIT(config)#telemetry model-driven
RP/0/RP1:SIT(config-model-driven)#sensor-group CPU-MONITORING
```

```
RP/0/RP1:SIT(config-model-driven-snsr-grp)#sensor-path Cisco-IOS-XR-wdsysmon-fd-oper:system-monitoring
RP/0/RP1:SIT(config-model-driven-snsr-grp)#commit
Sun Sep  6 19:38:01.372 IST
RP/0/RP1:SIT(config-model-driven-snsr-grp)#end
```

where -

- `CPU-MONITORING` is the name of the sensor-group
- `Cisco-IOS-XR-wdsysmon-fd-oper:system-monitoring` is the sensor path from where data is streamed.

Step 3 Subscribe to telemetry data that is streamed from a router. A Subscription, on page 8 binds the destination-group with the sensor-group and sets the streaming method. The streaming method can be Cadence-driven Telemetry, on page 4 or Event-driven Telemetry, on page 5.

Example:

Note The configuration for event-driven telemetry is similar to cadence-driven telemetry, with only the sample interval as the differentiator. Configuring the sample interval value to `0`, zero, sets the subscription for event-driven telemetry, while configuring the interval to any non-zero value sets the subscription for cadence-driven telemetry.

Create a subscription using data model

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="101">
  <edit-config>
    <target>
      <candidate/>
    </target>
    <config>
      <telemetry-model-driven
xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-um-telemetry-model-driven-cfg">
        <subscriptions>
          <subscription>
            <subscription-identifier>CPU-Utilization</subscription-identifier>
            <sensor-profiles>
              <sensor-profile>
                <sensorgroupid>CPU-MONITORING</sensorgroupid>
                <sample-interval>6000</sample-interval>
              </sensor-profile>
            </sensor-profiles>
            <destination-profiles>
              <destination-profile>
                <destination-id>CPU-Health</destination-id>
              </destination-profile>
            </destination-profiles>
          </subscription>
        </subscriptions>
      </telemetry-model-driven>
    </config>
  </edit-config>
</rpc>
```

Create a subscription using CLI

```
RP/0/RP1:SIT#configure
Sun Sep  6 19:39:17.564 IST
RP/0/RP1:SIT(config)#telemetry model-driven
RP/0/RP1:SIT(config-model-driven)#subscription CPU-Utilization
RP/0/RP1:SIT(config-model-driven-subs)#sensor-group-id CPU-MONITORING sample-interval  6000
RP/0/RP1:SIT(config-model-driven-subs)#des
describe  destination-id
```

```
RP/0/RP1:SIT(config-model-driven-subs)#destination-id CPU-Health
RP/0/RP1:SIT(config-model-driven-subs)#commit
Sun Sep  6 19:40:31.221 IST
RP/0/RP1:SIT(config-model-driven-subs)#end
```

where -

- `CPU-Utilization` is the name of the subscription
- `CPU-MONITORING` is the name of the sensor-group
- `CPU-Health` is the name of the destination-group
- `6000` is the sample interval in milliseconds. The sample interval is the time interval between two streams of data.

Verify Deployment of the Subscription

The router dials out to the receiver to establish a session with each destination in the subscription. After the session is established, the router streams data to the receiver to create a data lake.

You can verify the deployment of the subscription on the router.

Step 1 View the model-driven telemetry configuration on the router.

Example:

```
Router#show running-config telemetry model-driven
Sun Sep  6 19:46:25.869 IST
telemetry model-driven
destination-group CPU-Health
  address-family ipv4 209.165.201.1 port 4321
   encoding json
   protocol tcp
  !
!
sensor-group CPU-MONITORING
  sensor-path Cisco-IOS-XR-wdsysmon-fd-oper:system-monitoring
!
subscription CPU-Utilization
  sensor-group-id CPU-MONITORING sample-interval 6000
  destination-id CPU-Health
!
!
```

Step 2 Verify the state of the subscription. An `Active` state indicates that the router is ready to stream data to the receiver based on the subscription.

Example:

```
Router# show telemetry model-driven subscription CPU-Utilization
Sun Sep  6 19:44:07.659 IST
Subscription:  CPU-Utilization
-------------
  State:       NA
  Sensor groups:
  Id: CPU-MONITORING
    Sample Interval:      6000 ms
    Sensor Path:          Cisco-IOS-XR-wdsysmon-fd-oper:system-monitoring
```

```
  Sensor Path State:    Resolved

Destination Groups:
Group Id: CPU-Health
  Destination IP:       209.165.201.1
  Destination Port:     4321
  Encoding:             json
  Transport:            tcp
  State:                NA
  No TLS

Collection Groups:
------------------
No active collection groups
```

The router streams data to the receiver using the subscription-based telemetry session and creates a data lake in the receiver.

Operate on Telemetry Data for In-depth Analysis of the Network

You can start consuming and analyzing telemetry data from the data lake using an open-sourced collection stack. This use case uses the following tools from the collection stack:

- Pipeline is a lightweight tool used to collect data. You can download Network Telemetry Pipeline from Github. You define how you want the collector to interact with routers and where you want to send the processed data using `pipeline.conf` file.
- Telegraph (plugin-driven server agent) and InfluxDB (a time series database (TSDB)) stores telemetry data, which is retrieved by visualization tools. You can download InfluxDB from Github. You define what data you want to include into your TSDB using the `metrics.json` file.
- Grafana is a visualization tool that displays graphs and counters for data streamed from the router.

In summary, Pipeline accepts TCP telemetry stream, converts data and pushes data to the InfluxDB database. Grafana uses the data from InfluxDB database to build dashboards and graphs. Pipeline and InfluxDB may run on the same server or on different servers.

Consider that the router is streaming data of approximately 350 counters every 5 seconds, and Telegraf requests information from the Pipeline at 1 second intervals. The CPU usage is analysed in three stages using:

- a single router to get initial values
- two routers to find the difference in values and understand the pattern
- five routers to arrive at a proof-based conclusion

This helps you make informed business decisions about deploying the infrastructure; in this case, the CPU.

Step 1 Start Pipeline, and enter your router credentials.

Note The IP address and port that you specify in the destination-group must match the IP address and port on which Pipeline is listening.

Example:

```
$ bin/pipeline -config pipeline.conf

Startup pipeline
Load config from [pipeline.conf], logging in [pipeline.log]

CRYPT Client [mymdtrouter], [http://172.0.0.0:5432]
 Enter username: <username>
 Enter password: <password>
Wait for ^C to shutdown
```

Step 2 In the Telegraph configuration file, add the following values to read the metrics about CPU usage.

Example:

```
[[inputs.cpu]]
  ## Whether to report per-cpu stats or not
  percpu = true
  ## Whether to report total system cpu stats or not
  totalcpu = true
  ## If true, collect raw CPU time metrics.
  collect_cpu_time = false
  ## If true, compute and report the sum of all non-idle CPU states.
  report_active = false
```

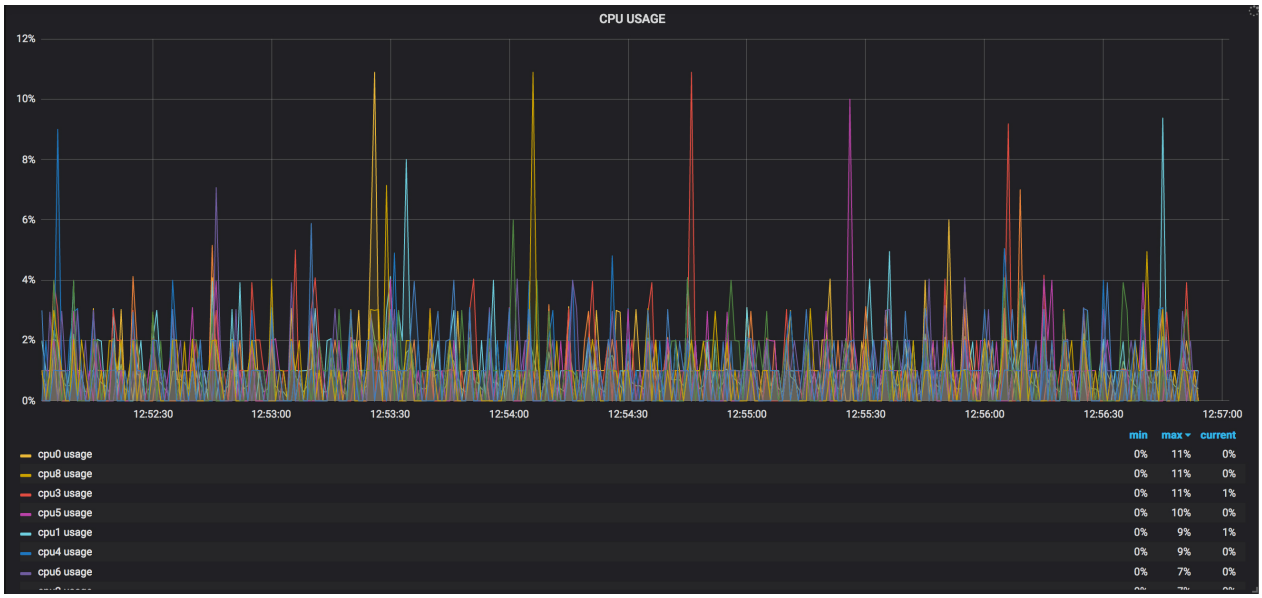
Step 3 Use Grafana to create a dashboard and visualize data about CPU usage.

One router

The router pushes the counters every five seconds.

All CPU cores are loaded equally, and there are spikes up to approximately 10 or 11 percent.

Figure 6: CPU Usage Graph with a Single Router

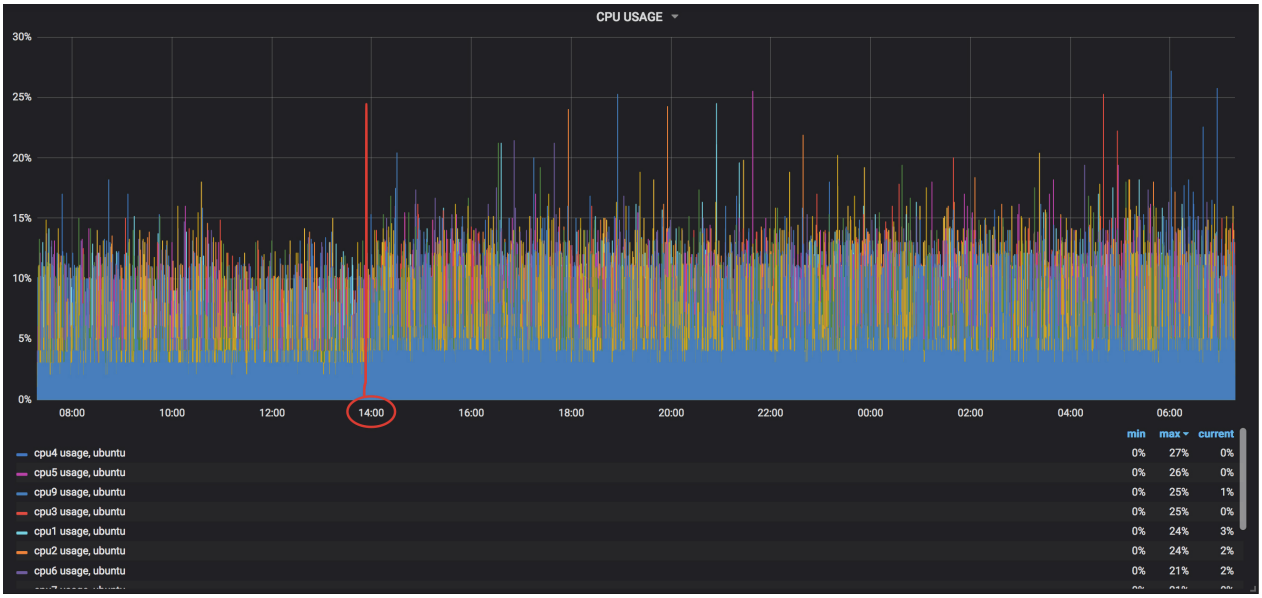


369756

Two routers

The second router is added at `14:00` in the timeline, and shows an increase in the spikes to around 25 percent with midpoint value at 15 percent.

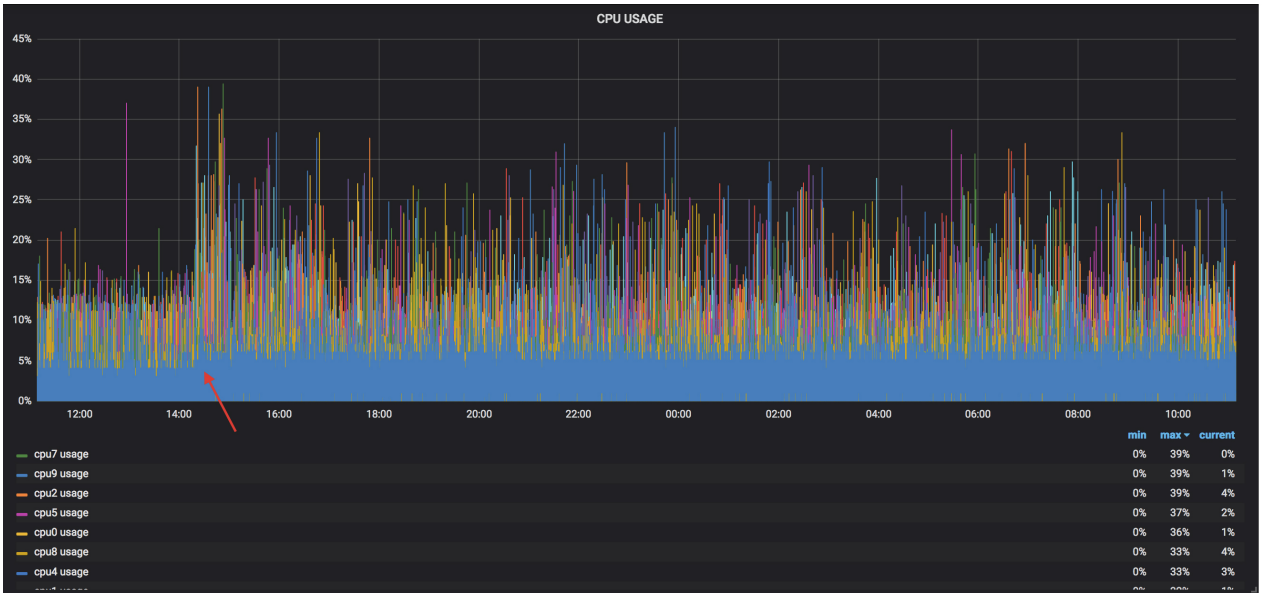
Figure 7: CPU Usage Graph with Two Routers



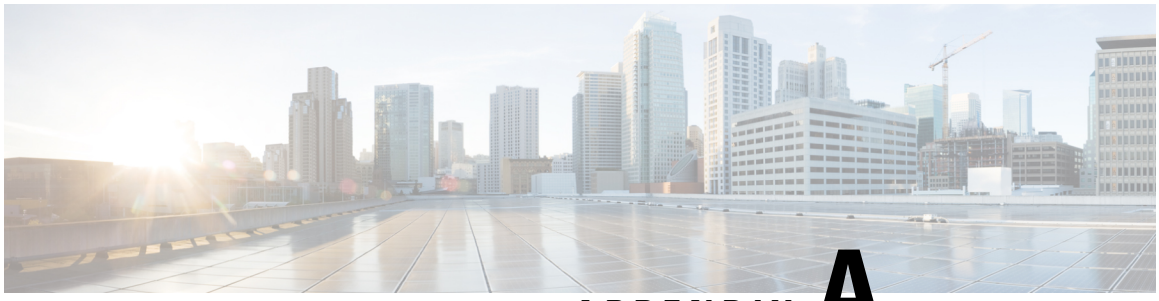
Five routers

With five routers, the spikes peak upto approximtely 40 percent with midpoint in the range of 22 to 25 percent.

Figure 8: CPU Usage Graph with Five Routers



In conclusion, telemetry data shows that the processes are balanced almost equally across the CPU cores. There is no linear increase on a subset of cores. This analysis helps in planning the CPU utilization based on the number of counters that you stream.



APPENDIX A

Supported Sensor Paths

The complete list of supported sensor paths are listed below.

```
sensor-path Cisco-IOS-XR-ifmgr-oper:interface-dampening
sensor-path Cisco-IOS-XR-crypto-ssh-oper:ssh1
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-tp
sensor-path Cisco-IOS-XR-bundlemgr-oper:bundles
sensor-path Cisco-IOS-XR-l2-eth-infra-oper:vlan
sensor-path Cisco-IOS-XR-lmp-oper:lmp/clients
sensor-path Cisco-IOS-XR-qos-ma-oper:qos/nodes
sensor-path Cisco-IOS-XR-bundlemgr-oper:lacp-data
sensor-path Cisco-IOS-XR-ip-rsvp-oper:rsvp/issu
sensor-path Cisco-IOS-XR-lmp-oper:lmp/gmpls-uni
sensor-path Cisco-IOS-XR-ip-bfd-oper:bfd/counters
sensor-path Cisco-IOS-XR-ip-iep-oper:explicit-paths
sensor-path Cisco-IOS-XR-ip-rsvp-oper:rsvp/counters
sensor-path Cisco-IOS-XR-lmp-oper:lmp/global-status
sensor-path Cisco-IOS-XR-qos-ma-oper:qos/qos-global
sensor-path Cisco-IOS-XR-ethernet-cfm-oper:cfm/nodes
sensor-path Cisco-IOS-XR-ethernet-cfm-oper:cfm/global
sensor-path Cisco-IOS-XR-ip-bfd-oper:bfd/session-mibs
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/tunnels
sensor-path Cisco-IOS-XR-qos-ma-oper:qos/nv-satellite
sensor-path Cisco-IOS-XR-ip-bfd-oper:bfd/client-briefs
sensor-path Cisco-IOS-XR-ip-bfd-oper:bfd/label-summary
sensor-path Cisco-IOS-XR-ip-bfd-oper:bfd/client-details
sensor-path Cisco-IOS-XR-ip-rsvp-oper:rsvp/bw-pool-info
sensor-path Cisco-IOS-XR-ip-rsvp-oper:rsvp/nsr/status
sensor-path Cisco-IOS-XR-l2-eth-infra-oper:mac-accounting
sensor-path Cisco-IOS-XR-lmp-oper:lmp/component-link-ids
sensor-path Cisco-IOS-XR-qos-ma-oper:qos/interface-table
sensor-path Cisco-IOS-XR-alarmgr-server-oper:alarms/brief
sensor-path Cisco-IOS-XR-ip-iep-oper:explicit-paths/names
sensor-path Cisco-IOS-XR-ip-bfd-oper:bfd/generic-summaries
sensor-path Cisco-IOS-XR-lmp-oper:lmp/gmpls-uni/te-links
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/affinity-map
sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/config-instances
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/bfd/summary
sensor-path Cisco-IOS-XR-qos-ma-oper:qos/nv-interface-table
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/attribute-sets
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/bfd/counters
sensor-path Cisco-IOS-XR-ifmgr-oper:interface-dampening/nodes
sensor-path Cisco-IOS-XR-ip-bfd-oper:bfd/label-session-briefs
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/maximum-tunnels
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/path-protection
sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/bpm-instances-table
sensor-path Cisco-IOS-XR-ip-iep-oper:explicit-paths/identifiers
```

Supported Sensor Paths

```
sensor-path Cisco-IOS-XR-l2-eth-infra-oper:ethernet-encapsulation
sensor-path Cisco-IOS-XR-ip-iep-oper:explicit-paths/names/name
sensor-path Cisco-IOS-XR-ip-rsvp-oper:rsvp/global-neighbor-briefs
sensor-path Cisco-IOS-XR-infra-policymgr-oper:policy-manager/nodes
sensor-path Cisco-IOS-XR-l2vpn-oper:l2vpnv2/active/xconnect-brief
sensor-path Cisco-IOS-XR-bundlemgr-oper:bundle-information/system-id
sensor-path Cisco-IOS-XR-bundlemgr-oper:lacp-bundles/bundles/bundle
sensor-path Cisco-IOS-XR-ip-rsvp-oper:rsvp/interface-neighbor-details
sensor-path Cisco-IOS-XR-policy-repository-oper:routing-policy/limits
sensor-path Cisco-IOS-XR-alarmgr-server-oper:alarms/brief/brief-system
sensor-path Cisco-IOS-XR-alarmgr-server-oper:alarms/detail/detail-card
sensor-path Cisco-IOS-XR-bundlemgr-oper:bundle-information/bundle-briefs
sensor-path Cisco-IOS-XR-controller-odu-oper:odu/controllers/controller
sensor-path Cisco-IOS-XR-controller-otu-oper:otu/controllers/controller
sensor-path Cisco-IOS-XR-alarmgr-server-oper:alarms/detail/detail-system
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/soft-preemption/statistics
sensor-path Cisco-IOS-XR-clns-isis-oper:isis/instances/instance/neighbors
sensor-path Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/summary
sensor-path Cisco-IOS-XR-ifmgr-oper:interface-dampening/interfaces/interface
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/next-hop-routes/next-hop-route
sensor-path Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/class-map
sensor-path Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/policy-map
sensor-path Cisco-IOS-XR-ipv4-io-oper:ipv4-network/nodes/node/interface-data
sensor-path Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/global/active/default-vrf/issu
sensor-path Cisco-IOS-XR-mpls-te-oper:mpls-te/nsr/status/sync-status-information
sensor-path Cisco-IOS-XR-ipv4-ospf-oper:ospf/processes/process/vrfs/vrf/areas
sensor-path Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/optics-port
sensor-path Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/global/active/default-vrf/summary
sensor-path Cisco-IOS-XR-ipv4-ospf-oper:ospf/processes/process/default-vrf/mpls-te
sensor-path Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/global/active/forwarding-summary-all
sensor-path Cisco-IOS-XR-policy-repository-oper:routing-policy/policies/route-policies
sensor-path Cisco-IOS-XR-ipv4-ospf-oper:ospf/processes/process/default-vrf/statistics
sensor-path Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/target-policy-map-types

sensor-path Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/policy-map-applied-types

sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/attributes
sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/rt-entries
sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/rpki-routes

sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/attributes

sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/rt-entries

sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/rpki-summary

sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/rpki-routes

sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/label-entries

sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/label-summary

sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/rpki-summary

sensor-path Cisco-IOS-XR-ipv4-ospf-oper:ospf/processes/process/default-vrf/flood-list-table

sensor-path
Cisco-IOS-XR-mpls-te-oper:mpls-te/attribute-sets/attribute-set/attribute-set-union
sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/bmp

sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/bmp
sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/label-rpf-entries
```

```
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/rpki-server-list
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/bmp

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/bmp
  sensor-path
Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/transient-policy-map-applied-types
  sensor-path
Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/transient-policy-map-targets-types
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/postits
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/postits
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/sessions
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/postits
  sensor-path
Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/global/active/default-vrf/capabilities/capability
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/sessions
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/neighbors
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/postits
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/sessions
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/attribute-filter-groups
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/neighbors
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/sessions
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/neighbors
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/information
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/attribute-filter-groups
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/neighbors
  sensor-path
Cisco-IOS-XR-bundlemgr-oper:bundles-adjacency/nodes/node[node-name="0/RP0"]/brief
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/information
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/update-generation-process

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/message-logs
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/next-hop-vrf
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/process-info
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/information
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/message-logs
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/next-hop-vrf
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/process-info
  sensor-path
```

Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/information
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/update-generation-process

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/message-logs
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/next-hop-vrf
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/process-info
  sensor-path
Cisco-IOS-XR-ip-bfd-oper:bfd/session-details/session-detail/status-information/source-address

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/message-logs

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/next-hop-vrf

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/process-info

  sensor-path
Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/optics-port/optics-info/ains-info

  sensor-path
Cisco-IOS-XR-ip-bfd-oper:bfd/session-details/session-detail/status-information/transmit-packet

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/update-inbound-error-process

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/epes
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/neighbor-ranges
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/epes
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/neighbor-ranges

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/update-inbound-filter-process

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/update-inbound-error-process

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/epes
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/neighbor-ranges

  sensor-path
Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/optics-port/optics-info/laser-state

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/epes
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/neighbor-ranges

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/update-inbound-filter-process

  sensor-path
Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/optics-port/optics-info/optics-module

```
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/networks
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/policies
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/rpc-sets
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/global-process-info

  sensor-path
Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/global/active/default-vrf/statistics/statistic/message-out

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/networks

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/policies

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/rpc-sets

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/global-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/bmp-paths

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/networks

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/policies

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/rpc-sets

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/global-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/bmp-paths

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/attributes

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/dampenings

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/path-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/networks

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/policies

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/rpc-sets

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/global-process-info
```

```
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/bmp-paths

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/attributes

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/dampenings

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/path-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/convergence

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/bmp-paths

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/attributes

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/dampenings

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/path-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/convergence

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/attributes

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/dampenings

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/path-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/convergence

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/update-groups

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/update-inbound-error-vrf

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/convergence

  sensor-path Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/
  optics-port/ots-spectrum-info/spectrum-info
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/update-groups

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/update-inbound-error-vrf

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/prefix-filters

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/update-inbound-filter-vrf
```

```
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/update-groups

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/update-inbound-error-vrf

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/prefix-filters

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/update-inbound-filter-vrf

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/af-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/path-used-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/rt-set-counters

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/update-groups

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/update-inbound-error-vrf

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/prefix-filters

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/update-inbound-filter-vrf

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/af-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/path-used-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/rt-set-counters

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/advertised-paths

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/sourced-networks

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/prefix-filters

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/update-inbound-filter-vrf

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/af-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/path-used-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/rt-set-counters
```

```
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/advertised-paths

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/sourced-networks

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/neighbor-af-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/af-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/path-used-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/rt-set-counters

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/advertised-paths

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/sourced-networks

  sensor-path Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/
  optics-port/optics-dwdm-carrier-channel-map-flexi
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/neighbor-af-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/advertised-path-xr

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/path-labeled-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/advertised-paths

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/sourced-networks

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/neighbor-af-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/advertised-path-xr

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/path-labeled-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/update-inbound-error-neighbors

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/neighbor-af-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/advertised-path-xr

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/path-labeled-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/update-inbound-error-neighbors
```

```
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/update-inbound-filter-neighbors

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/advertised-path-xr

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/path-labeled-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/update-inbound-error-neighbors

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/update-inbound-filter-neighbors

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/rpki-refresh-af-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/update-inbound-error-neighbors

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/update-inbound-filter-neighbors

  sensor-path
Cisco-IOS-XR-ipv4-ospf-oper:ospf/processes/process/default-vrf/route-information/backup-routes/backup-route

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/rpki-refresh-af-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/advertised-path-counts

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/bmp-path-table-generic

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/global-af-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/update-inbound-filter-neighbors

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/rpki-refresh-af-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/advertised-path-counts

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/bmp-path-table-generic

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/default-vrf/afs/af/global-af-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/rpki-refresh-af-table

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/advertised-path-counts

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/bmp-path-table-generic
```

```
  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/vrfs/vrf/afs/af/global-af-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/advertised-path-counts

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/bmp-path-table-generic

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/default-vrf/afs/af/global-af-process-info

  sensor-path
Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/vrfs/vrf/afs/af/next-hop-address-families

  sensor-path Cisco-IOS-XR-clns-isis-oper:ocni-isis/network-instances/network-instance/
  protocols/protocol/isis/isis-interfaces
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  default-vrf/afs/af/next-hop-address-families
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  vrfs/vrf/afs/af/next-hop-address-families
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  vrfs/vrf/afs/af/update-generation-neighbors
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  default-vrf/afs/af/next-hop-address-families
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  default-vrf/afs/af/update-generation-neighbors
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  vrfs/vrf/afs/af/update-generation-sub-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  vrfs/vrf/afs/af/update-generation-neighbors
  sensor-path
Cisco-IOS-XR-ip-bfd-oper:bfd/label-session-briefs/label-session-brief/status-brief-information/echo-interval-multiplier

  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  default-vrf/afs/af/update-generation-sub-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  default-vrf/afs/af/update-generation-neighbors
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  vrfs/vrf/afs/af/update-generation-sub-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  default-vrf/afs/af/update-generation-sub-groups
  sensor-path Cisco-IOS-XR-mpls-ldp-oper:mpls-ldp/global/active/default-vrf/
  neighbors/neighbor/detailed-information/capabilities
  sensor-path Cisco-IOS-XR-bundlemgr-oper:bundle-information/bundle/bundle-bundles/
  bundle-bundle/bundle-bundle-descendant/bundle-data
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  vrfs/vrf/afs/af/update-generation-filter-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  vrfs/vrf/afs/af/update-generation-update-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  default-vrf/afs/af/update-generation-filter-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  default-vrf/afs/af/update-generation-update-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  vrfs/vrf/afs/af/update-generation-address-family
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  vrfs/vrf/afs/af/update-generation-filter-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  vrfs/vrf/afs/af/update-generation-update-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-active/
  default-vrf/afs/af/update-generation-address-family
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  default-vrf/afs/af/update-generation-filter-groups
```

```
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  default-vrf/afs/af/update-generation-update-groups
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  vrfs/vrf/afs/af/update-generation-address-family
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/instances/instance/instance-standby/
  default-vrf/afs/af/update-generation-address-family
  sensor-path Cisco-IOS-XR-controller-optics-oper:optics-oper/optics-ports/
  optics-port/optics-dwdm-carrier-channel-map/dwdm-carrier-map-info
  sensor-path Cisco-IOS-XR-pmengine-oper:performance-management/otu/otu-ports/
  otu-port/otu-current/otu-minute15/otu-minute15otns/otu-minute15otn/uas-ne
  sensor-path Cisco-IOS-XR-pmengine-oper:performance-management/otu/otu-ports/
  otu-port/otu-current/otu-minute15/otu-minute15otns/otu-minute15otn/uas-ne/data
  sensor-path Cisco-IOS-XR-ipv4-bgp-oper:bgp/config-instances/config-instance/
  config-instance-default-vrf/entity-configurations/entity-configuration/
  neighbor-address-xr
  sensor-path Cisco-IOS-XR-pmengine-oper:performance-management-history/
  global/periodic/optics-history/optics-port-histories/optics-port-history/
  optics-minute15-history
  sensor-path Cisco-IOS-XR-pmengine-oper:performance-management/optics/
  optics-ports/optics-port/optics-current/optics-minute15/optics-minute15-optics/
  optics-minute15-optic
  sensor-path
Cisco-IOS-XR-pmengine-oper:performance-management-history/global/periodic/otu-history/
  otu-port-histories/otu-port-history/otu-minute15-history/
  otu-minute15otn-histories/otu-minute15otn-history/otu-minute15otn-time-line-instances/
  otu-minute15otn-time-line-instance/uas-ne
```

Supported Sensor Paths