



## Enhancements to Streaming Telemetry

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This section provides an overview of the enhancements made to streaming telemetry data.

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# Hardware Timestamp

Table 1: Feature History Table

Feature Name	Release Information	Description
Enhancements to Hardware Timestamp	Release 7.3.4	<p>Telemetry messages carry a timestamp per interface to indicate the time when data is collected from the hardware. With this feature, the support for hardware timestamp is extended to MPLS Traffic Engineering (MPLS TE) counters, Segment Routing for Traffic Engineering (SR-TE) interface counters, protocol statistics, and bundle protocol counters.</p> <p>The interface counters in the following paths are enhanced for hardware timestamp:</p> <ul style="list-style-type: none"> <li>• Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/cache/generic-counters</li> <li>• Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/latest/generic-counters</li> <li>• openconfig-network-instance:network-instances/network-instance/mpls/lsp/constrained-path/tunnels</li> <li>• openconfig-interfaces:interfaces/interface</li> </ul>
Hardware Timestamp	Release 7.3.1	<p>Whenever periodic statistics are streamed, the collector reads the data from its internal cache, instead of fetching the data from the hardware.</p> <p>When the data is read from the cache, the rate at which data is processed shows spikes because the timestamp from the collector is off by several seconds. With hardware timestamping, the inconsistencies that are observed when reading data from the cache file is removed.</p>

Whenever periodic stats are streamed, the collector reads the stats from its internal cache, instead of fetching the stats from the hardware. When the data is read from the sensor paths of Stats manager cache, the rate calculation shows spikes. This behavior is due to the timestamp from the collector that is off by several seconds.

Therefore, timestamp of some other collector takes precedence because timestamps of collectors are not in synchronization with the current timestamp. This is observed when there are multiple collectors providing stats updates for the same interface.

The YANG data model for Stats manager `Cisco-IOS-XR-infra-statsd-oper.yang` is enhanced to enable the collector to read periodic stats data from the router using hardware timestamp.

The hardware timestamp is taken into account when a primary collector (for generic or proto stats) provides stats updates from the hardware to the Stats manager. With hardware timestamping in rate computation while streaming periodic stats, the spikes due to the timestamp issue is resolved.

The hardware timestamp is updated only when the collector attempts to read the counters from hardware. Else, the value remains 0. The latest stats can be streamed at a minimum cadence of 10 seconds and periodic stats at a cadence of 30 seconds. The support is available only for physical interfaces and subinterfaces, and bundle interface and subinterfaces.

When there is no traffic flow on protocols for an interface, the hardware timestamp for the protocols is published as 0. This is due to non-synchronized timestamps sent by the collector for protocols in traffic as compared to non-traffic scenarios.

A non-zero value is published for protocols that have stats published by a primary collector for both traffic and non-traffic scenarios.



**Note** The hardware timestamp is supported only for primary collectors. When the hardware has no update, the timestamp will be same. However generic counters are computed for primary and non-primary collectors. The non-primary collectors show the latest stats, but not the timestamp.

When the counters are cleared for an interface using **clear counters interface** command, all counter-related data including the timestamps for the interface is cleared. After all counter values are cleared and set to 0, the last data time is updated only when there is a request for it from a collector. For example, last data time gets updated from a collector:

```
Router#:Aug 7 09:01:08.471 UTC: statsd_manager_1[168]: Updated last data time for ifhandle
0x02000408,
stats type 2 from collector with node 0x100, JID 250, last data time 1596790868.
INPUT: last 4294967295 updated 1596469986. OUTPUT: last 4294967295 updated 1596469986
```

All other counter values and hardware timestamp are updated when the counters are fetched from the hardware. In this case, all counters including the hardware timestamp is 0:

```
{ "node_id_str": "MGBL_MTB_5504", "subscription_id_str": "app_TEST_200000001",
"encoding_path": "Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/cache/generic-counters",
"collection_id": "7848",
"collection_start_time": "1596790879567",
"msg_timestamp": "1596790879571", "data_json":
[ { "timestamp": "1596790879570", "keys": { "interface-name": "FortyGigE0/1/0/11" },
"content": { "packets-received": "0", "bytes-received": "0", "packets-sent": "0",
"bytes-sent": "0", "multicast-packets-received": "0", "broadcast-packets-received": "0",
"multicast-packets-sent": "0", "broadcast-packets-sent": "0", "output-drops": "0", "output-queue-drops": "0",
"input-drops": "0", "input-queue-drops": "0", "runt-packets-received": "0", "giant-packets-received": "0",
"throttled-packets-received": "0", "parity-packets-received": "0", "unknown-protocol-packets-received": "0",
"input-errors": "0", "crc-errors": "0", "input-overruns": "0", "framing-errors-received": "0", "input-ignored-packets": "0",
"input-aborts": "0", "output-errors": "0", "output-underruns": "0", "output-buffer-failures": "0", "output-buffers-swapped-out": "0",
"applique": "0", "resets": "0", "carrier-transitions": "0", "availability-flag": "0",
"last-data-time": "1596790868", "hardware-timestamp": "0",
"seconds-since-last-clear-counters": "15", "last-discontinuity-time": "1596469946", "seconds-since-packet-received": "0",
"seconds-since-packet-sent": "0" } } ], "collection_end_time": "1596790879571" }
```

# Monitor Process State via Event-Driven Telemetry

Table 2: Feature History Table

Feature Name	Release Information	Description
Monitor Process State via Event-Driven Telemetry (EDT)	Release 7.4.2	With this feature, you can configure the list of processes you want to monitor, and receive notifications via event-driven telemetry when the configured process restarts or crashes.  This feature introduces the <b>process-state-monitor location</b> command to monitor processes on specific nodes or all nodes.

You can monitor the state of Cisco IOS XR processes using event-driven telemetry (EDT) notifications.

You can use the **process-state-monitor location** [*node* | **all**] command or **Cisco-IOS-XR-wd-proc-state-cfg.yang** data model to perform the following operations:

- Configure the list of process names to register for EDT notifications for a specific node or for all nodes.
- Receive notification via EDT about the end of the configured processes.

**Step 1** Register the processes that you want to monitor and receive notifications:

- Configure the process for a specific node.

### Configure via CLI:

```
Router (config) #process-state-monitor location 0/RP1/CPU0
Router (config-set-proc-name) #process-name l2vpn_mgr
Router (config-set-proc-name) #process-name ipv4_rib
Router (config-set-proc-name) #process-name ipv6_rib
Router (config-set-proc-name) #exit
Router (config) #process-state-monitor location 0/1/CPU0
Router (config-set-proc-name) #process-name l2fib_mgr
Router (config-set-proc-name) #commit
```

### Configure via Data Model:

```
<process-state-monitor-node-specific
xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-wd-proc-state-cfg">
  <node>
    <node>0/0/CPU0</node>
    <process-state-monitor>
      <process-names>
        <process-name>
          <process-name>l2fib_mgr</process-name>
        </process-name>
      </process-names>
    </process-state-monitor>
  </node>
  <node>
    <node>0/RP0/CPU0</node>
    <process-state-monitor>
      <process-names>
        <process-name>
```

```

    <process-name>l2vpn_mgr</process-name>
  </process-name>
</process-name>
  <process-name>ipv4_rib</process-name>
</process-name>
  <process-name>
    <process-name>ipv6_rib</process-name>
  </process-name>
</process-names>
</process-state-monitor>
</node>
</process-state-monitor-node-specific>

```

**Note** The configuration that you apply to active RP is not synchronized with the standby RP. So on switch over, the processes that are monitored on old active RP are not monitored on the new active RP.

If a process is configured under a specific location (such as RP0, LC0, LC1 and so on), and if you configure the same process under the same node, then the configuration is applied successfully. However, the process will not be registered again with the process manager to avoid receiving duplicate notifications.

- Configure the process on all the nodes.

#### Configure via CLI:

```

Router (config) #process-state-monitor location all
Router (config-set-proc-name) #process-name dumper
Router (config-set-proc-name) #commit

```

#### Configure via Data Model:

```

<process-state-monitor xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-wd-proc-state-cfg">
  <location>
    <all>
      <process-names>
        <process-name>
          <process-name>dumper</process-name>
        </process-name>
      </process-names>
    </all>
  </location>
</process-state-monitor>

```

**Note** In addition to the active RP, if the configuration must be applied to the standby RP, then provide the location of standby RP when configuring the process. If the configuration is applicable to all nodes (RP, LC) then select the location as `all`.

If the process is configured for all locations, and if you configure the same process under some other location (such as RP0, LC0, LC1 and so on), then the commit operation fails with an error message. When a process on any one of the nodes has already reached the maximum limit, the configuration is not applied on that node.

To remove the configuration, use the **no** form of the command. For example, the process to monitor the L2VPN manager is removed from the configuration:

```
Router (config-monitor-proc-name) #no process-name l2vpn_mgr
```

- Step 2** View the configuration applied on the router.

#### Example:

```

Router#show running-config
Thu Feb 3 06:12:00.014 UTC
Building configuration...
!! IOS XR Configuration 7.4.2

```

```

!! Last configuration change at Thu Feb 3 06:11:50 2022 by cisco
!
username cisco
group root-lr
group cisco-support!
call-home
service active
contact smart-licensing
profile Test
active
destination transport-method email disable
destination transport-method http
!
!
process-state-monitor location all
  process-name dumper
!
process-state-monitor location 0/0/CPU0
  process-name l2fib_mgr
!
process-state-monitor location 0/RP0/CPU0
  process-name l2vpn_mgr
!

```

The following is a sample EDT notification that shows the data that is collected when the process restarts or crashes:

```

node_id_str: "ios"
subscription_id_str: "proc-state"
encoding_path: "Cisco-IOS-XR-wd-proc-state-oper:process-death-notification/process-death-info"
model_version: "2019-04-05"
collection_id: 1
collection_start_time: 1623890312688
msg_timestamp: 1623890312688
data_gpbkv {
  timestamp: 1623890312680
  fields {
    name: "content"
    fields {
      name: "location"
      string_value: "0_RP0_CPU0"
    }
    fields {
      name: "process-name"
      string_value: "l2vpn_mgr"
    }
    fields {
      name: "pid"
      uint32_value: 9743
    }
    fields {
      name: "jid"
      uint32_value: 1182
    }
  }
}
}

```

---

# Target-Defined Mode for Cached Generic Counters Data

Table 3: Feature History Table

Feature Name	Release Information	Description
Target-Defined Mode for Cached Generic Counters Data	Release 7.5.1 Release 7.3.3	<p>This feature streams telemetry data for cached generic counters using a TARGET_DEFINED subscription. This subscription ensures that any change to the cache streams the latest data to the collector as an event-driven telemetry notification.</p> <p>This feature introduces support for the following sensor path:</p> <pre>Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/cache/generic-counters</pre>

Streaming telemetry pushes the subscribed data from the router to one or more collectors. The telemetry infrastructure retrieves the data from the system database when you send a subscription request. Based on the subscription request or the telemetry configuration the cached generic counters data can be retrieved periodically based on the sample-interval. Data, such as interface statistics, is cached and refreshed at certain intervals. The TARGET\_DEFINED subscription mode can be used to retrieve data when the cache gets updated, and is not based on a timer.

The application can register as a data producer with the telemetry library and the SysdB paths it supports. One of the data producers, Statsd, uses the library with a TARGET\_DEFINED subscription mode. As part of this mode, the producer registers the sensor paths. The statistics infrastructure streams the incremental updates for statsd cache sensor path

`Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/cache/generic-counters`. With this path in the subscription, whenever cache is updated, the statsd application pushes the updates to the telemetry daemon. The daemon sends these incremental updates to the collector. The cache updates are pushed for physical interfaces, physical subinterfaces, bundle interfaces, and bundle subinterfaces. You can subscribe to the sensor path for the cached generic counters with TARGET\_DEFINED mode instead of the sensor path for the latest generic counters (`Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/latest/generic-counters`) to reduce the system load.

Configure the router to stream telemetry data from cache for generic counters using the following instructions:

Create a TARGET\_DEFINED subscription mode for cached generic counters using one of the two options:

- **Option 1:** gRPC Network Management Interface (gNMI) subscribe request

```
{
  "name": "SubscribeRequest",
  "subscribe": {
    "prefix": {"origin":
      "Cisco-IOS-XR-infra-statsd-oper"
    },
  },
  "mode": "STREAM", "encoding": "PROTO", "updates_only": "false",
  "subscription": [
    { "path": {"elem": [ {"name": "infra-statistics"},
      {"name": "interfaces"}],
```

```

        {"name":"interface"},
        {"name":"cache"},
        {"name":"generic-counters"}
    ]
},
"mode": "TARGET_DEFINED"
}
}
}
}

```

- **Option 2:** Model-driven telemetry configuration for non-gNMI requests

```

Router(config)#telemetry model-driven
Router(config-model-driven)#subscription sub1
Router(config-model-driven-subs)#sensor-group-id grp1 mode target-defined
Router(config-model-driven-subs)#source-interface Interface1
Router(config-model-driven-subs)#commit

```

After the subscription is triggered, updates to the stats cache are monitored. The statsd application pushes the cached generic counters to the client (collector).

View the number of incremental updates for the sensor path.

```

Router#show telemetry model-driven subscription .*
Fri Nov 12 23:36:27.212 UTC
Subscription: GNMI__16489080148754121540
-----
Collection Groups:
-----
  Id: 1
  Sample Interval:      0 ms   (Incremental Updates)
  Heartbeat Interval:   NA
  Heartbeat always:    False
  Encoding:             gnmi-proto
  Num of collection:    1
  Incremental updates: 12
  Collection time:      Min:     5 ms Max:     5 ms
  Total time:          Min:     6 ms Avg:     6 ms Max:     6 ms
  Total Deferred:      1
  Total Send Errors:    0
  Total Send Drops:    0
  Total Other Errors:   0
  No data Instances:    0
  Last Collection Start:2021-11-12
                       23:34:27.1362538876 +0000
  Last Collection End:  2021-11-12  23:34:27.1362545589
                       +0000
  Sensor Path:         Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/
                       interface/cache/generic-counters

```

In this example, the incremental updates of 12 indicates that the cache is updated 12 times.

You can also retrieve the detailed operational data about the subscription using the following command. In this example, statsd-target is the subscription name.

```

Router#show telemetry model-driven subscription statsd-target internal
Fri Nov 12 08:51:16.728 UTC
Subscription: statsd-target
-----
State: ACTIVE
Sensor groups:
Id: statsd
Sample Interval: 0 ms (Incremental Updates)

```



```
Heartbeat Interval: NA
Sensor Path: Cisco-IOS-XR-infra-statsd-oper:infra-statistics/interfaces/interface/cache/
             generic-counters
Sensor Path State: Resolved

Destination Groups:
Group Id: statsd-target
Destination IP: 192.0.2.1
Destination Port: 56000
Encoding: json
Transport: grpc
State: Active
TLS : False
Total bytes sent: 623656
Total packets sent: 13
Last Sent time: 2021-08-16 08:51:15.1304821089 +0000

Collection Groups:
-----
Id: 2
Sample Interval: 0 ms (Incremental Updates)
Heartbeat Interval: NA
Heartbeat always: False
Encoding: json
Num of collection: 1
Incremental updates: 3
Collection time: Min: 94 ms Max: 94 ms
Total time: Min: 100 ms Avg: 100 ms Max: 100 ms
Total Deferred: 0
Total Send Errors: 0
Total Send Drops: 0
Total Other Errors: 0
No data Instances: 0
Last Collection Start:2021-08-16 08:51:04.1293895665 +0000
Last Collection End: 2021-08-16 08:51:04.1293996284 +0000
```

The sample interval of 0 indicates that the data is streamed whenever an event occurs. Here, the event represents the updates to the cache state.

#### Related Commands:

- **show tech telemetry model-driven**
- **show running-config telemetry model-driven**
- **show telemetry producers trace *producer name* info**
- **show telemetry producers trace *producer name* err**

## gNMI Dial-Out via Tunnel Service

gNMI supports a dial-in session where a client connects to the router via gRPC server with the gNMI specification. This feature introduces support to use a tunnel service for gNMI dial-out connections based on the recommendation from OpenConfig forum.

With the gNMI dial-out through tunnel service, the router (tunnel client) dials out to a collector (tunnel server). Once the session is established, the tunnel server can act as a client and request gNMI services and gNMI Subscribe RPCs over the tunnel session. This feature allows a change in direction of session establishment and data collection without altering the gNMI semantics. Using gRPC tunnel dial-out session, the router

initiates the connection to external collector so that the management software is automatically aware when a new device is introduced into the network.

For more information about gNMI dial-out via gRPC tunnel, see the [Github](#) repository.




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**Note** Only the gNMI Subscribe RPC over the tunnel is supported.

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**Note** The tunnel service supports only Transport Layer Security (TLS) session.

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Perform the following steps to configure gNMI dial-out via tunnel service:

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**Step 1** Configure a third-party application (TPA) source address. This address sets a source hint for Linux applications, so that the traffic originating from the applications can be associated to any reachable IP (IPv4 or IPv6) address on the router.

**Example:**

```
Router(config)#tpa
Router(config)#vrf default
Router(config-vrf)#address-family ipv4
Router(config-vrf)#update-source dataports TenGigE0/6/0/0/1
```

A default route is automatically gained in the Linux shell.

**Step 2** Configure the gNMI tunnel service on the router.

**Example:**

```
Router(config)#grpc tunnel destination ipv4
port 59510 source-interface TenGigE0/6/0/0/1 target Target-1 vrf default
```

Where—

- source-interface: Source ethernet interface
- target: Target name to register the tunnel service
- vrf: Virtual Routing and Forwarding (VRF) instance for the dial-out session. If VRF and source-interface are configured, VRF takes precedence over the source-interface.

**Step 3** Verify that the gRPC tunnel configuration is successful on the router.

**Example:**

```
Router#show run grpc
Wed Nov 24 19:37:21.015 UTC
grpc
port 57500
no-tls
tunnel
destination 5.0.0.2 port 59510
target Target-1
source-interface GigabitEthernet0/0/0/1
!
destination 2002::1:2 port 59510
source-interface GigabitEthernet0/0/0/0
!
```

```

destination 192.0.0.1 port 59500
!
destination 192.0.0.1 port 59600
!
!
!

```

**Step 4** View the status of tunnel destination.

**Example:**

```

Router#show grpc tunnel sessions
Wed Nov 24 19:41:38.863 UTC
5.0.0.2:59510
Target:          Target-1
Status:          Not connected
Error:           Source Interface is down
Source interface: GigabitEthernet0/0/0/1
Source address:  5.0.0.1
Source VRF:      default

[2002::1:2]:59510
Target:          Target-2
Status:          Connected
Source interface: GigabitEthernet0/0/0/0
Source address:  2002::1:1
Source VRF:      default
Last Connected:  2021-11-24 19:41:23

192.168.122.1:59500
Target:          Target-2
Status:          Connected
Last Connected:  2021-11-24 19:40:15

192.168.122.1:59600
Target:          Target-2
Status:          Not connected
Error:           cert missing /misc/config/grpc/192.0.0.1:59600.pem
Last Attempted:  2021-11-24 19:41:15

```

**Step 5** Copy the public certificate for the collector to `/misc/config/grpc/<ip-addr>:<port>.pem` directory. The router uses this certificate to verify the tunnel server, and establish a dial-out session.

**Step 6** Run the collector.

## Stream Telemetry Data about PBR Decapsulation Statistics

You can stream telemetry data about PBR decapsulation statistics for GRE and GUE encapsulation protocols that deliver packets using IPv4 or IPv6. The encapsulated data has source and destination address that must match with the source and destination address in the classmap. Both encapsulation and decapsulation interfaces collect statistics periodically. The statistics can be displayed on demand using **show policy-map type pbr [vrf vrf-name] address-family ipv4/ipv6 statistics** command. For more information on PBR-based decapsulation, see *Interface and Hardware Component Configuration Guide for Cisco ASR 9000 Series Routers*.

With this release, the decapsulation statistics can be displayed using `Cisco-IOS-XR-infra-policymgr-oper.yang` data model and telemetry data. You can stream telemetry data from the sensor path:

Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/policy-map/policy-map-types/policy-map-type/vrf-table/vrf/afi-table/afi/stats

The following steps show the PBR configuration and the decapsulation statistics that is streamed as telemetry data to the collector.

**Step 1** Check the running configuration to view the configured PBR per VRF.

**Example:**

```
Router#show running-config
Building configuration...
!! IOS XR Configuration 0.0.0
!!
vrf vrf1
  address-family ipv4 unicast
  !
  address-family ipv6 multicast
  !
!
netconf-yang agent
  ssh
!
!
class-map type traffic match-all cmap1
  match protocol gre
  match source-address ipv4 161.0.1.1 255.255.255.255
  match destination-address ipv4 161.2.1.1 255.255.255.255
end-class-map
!
policy-map type pbr gre-policy
  class type traffic cmap1
  decapsulate gre
  !
  class type traffic class-default
  !
end-policy-map
!
interface GigabitEthernet0/0/0/1
  vrf vrf1
  ipv4 address 2.2.2.2 255.255.255.0
  shutdown
!
vrf-policy
  vrf vrf1 address-family ipv4 policy type pbr input gre-policy
!
end
```

**Step 2** View the output of the VRF statistics.

**Example:**

```
Router#show policy-map type pbr vrf vrf1 addr-family ipv4 statistics
```

```
VRF Name:      vrf1
Policy-Name:   gre-policy
Policy Type:   pbr
Addr Family:   IPv4

Class:      cmap1
  Classification statistics      (packets/bytes)
  Matched          :      13387587/1713611136
  Transmitted statistics      (packets/bytes)
```

```

Total Transmitted      :      13387587/1713611136

Class:      class-default
Classification statistics      (packets/bytes)
  Matched      :      0/0
Transmitted statistics      (packets/bytes)
  Total Transmitted      :      0/0

```

After you have verified that the statistics are displayed correctly, stream telemetry data and check the streamed data at the collector. For more information about collectors, see *Operate on Telemetry Data for In-depth Analysis of the Network* section in the [Monitor CPU Utilization Using Telemetry Data to Plan Network Infrastructure](#) chapter.

```

ios.0/0/CPU0/ $ mdt_exec -s Cisco-IOS-XR-infra-policymgr-oper:policy-manager
/global/policy-map/policy-map-types/policy-map-type/vrf-table/vrf/afi-table/afi/stats -c 100
{"node_id_str":"ios","subscription_id_str":"app_TEST_200000001","encoding_path":
"Cisco-IOS-XR-infra-policymgr-oper:policy-manager/global/policy-map/policy-map-types/policy-map-type
/vrf-table/vrf/afi-table/afi/stats","collection_id":"1","collection_start_time":"1601361558157",
"msg_timestamp":"1601361559179","data_json":[{"timestamp":"1601361559178","keys":[{"type":"ipv6"},
{"vrf-name":"vrf_gue_ipv4"}, {"type":"ipv4"}],"content":{"pmap-name":"gre-policy","vrf-name":
"vrf1","appln-type":2,"addr-family":1,"rc":0,"plmgr-vrf-stats":[{"pmap-name":"gre-policy",
"cmmap-stats-arr":[{"cmmap-name":"cmmap1","matched-bytes":"1713611136","matched-packets":"13387587",
"transmit-bytes":"1713611136","transmit-packets":"13387587"}]}]}]}],
"collection_end_time":"1601361559183"}
----- snipped for brevity -----

```

