Juniper Networks | Engineering Simplicity

Overview for Junos OS Evolved

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Junos OS Evolved

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Overview for Junos OS Evolved

YEAR 2000 NOTICE

Juniper Networks hardware and software products are Year 2000 compliant. Junos OS has no known time-related limitations through the year 2038. However, the NTP application is known to have some difficulty in the year 2036.

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About This Guide

Use this guide to become acquainted with Junos OS Evolved, a unified, end-to-end network operating system. Learn about its strengths, similarities to, and differences from Junos OS.

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Overview of Junos OS Evolved

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Junos OS Evolved Overview

IN THIS SECTION

Junos OS Evolved is a unified, end-to-end network operating system that provides reliability, agility, and open programmability for successful cloud-scale deployments. With Junos OS Evolved, you can enable higher availability, accelerate your deployments, innovate more rapidly, and operate your network more efficiently. We've aligned Junos OS Evolved with Junos OS so that you can seamlessly continue to manage and to automate your network.

Benefits

Junos OS Evolved provides several benefits to Juniper Networks customers:

- It runs natively on Linux, providing direct access to all the Linux utilities and operations. With Linux integration, you can use standard Linux and open-source tools to speed up onboarding, accelerate feature adoption with a smooth upgrade process, and enjoy enhanced debugging capabilities for streamlined qualification and deployment.
- Support for 3rd party applications and tools. You can run Linux applications directly on Junos OS Evolved using Docker containers, or create custom applications for advanced networking solutions. You can use existing Linux tools and procedures to create custom functions on a developer-friendly platform with a short learning curve. This versatility allows you to create the solution that best fits your needs through simple third-party application integration and the ability to implement the components required for specific use cases.
- You can install multiple different Junos OS Evolved software releases on a device, with support for rolling back to previous versions. This gives you the flexibility to try out different software releases and easily revert back to your preferred version if necessary.

- Enhanced security at all OS layers. Junos OS Evolved uses an integrity solution called Integrity Measurement Architecture (IMA), and a companion mechanism called the Extended Verification Module (EVM). These open source protections are part of a set of Linux Security Modules that are industry-standard and consistent with the trust mechanisms specified by the Trusted Computing Group. Junos OS Evolved also supports other security features such as TPM infrastructure, hardened secure BIOS, and secure boot. Security is a core design principle for Junos OS Evolved. Juniper Networks is committed to maintaining a strong security infrastructure to keep your network safe and protected.
- Nearly all of the CLI and user interfaces are identical to those provided in Junos OS, meaning you can pick up Junos OS Evolved with a minimal learning curve. These similarities provide simplicity and operational consistency, minimizing the effort required to implement, maintain, and customize your end-to-end solution.

Native Linux Base

Whereas Junos OS runs over an instance of the FreeBSD operating system on a specific hardware element (for example, the CPU on the Routing Engine), Junos OS Evolved runs over a native Linux system. Having Linux as a base leverages a much wider, dynamic, and active development community. The Linux system also contains multiple third-party applications and tools developed for Linux that Junos OS Evolved can integrate with minimal effort.

The Junos OS Evolved infrastructure is a horizontal software layer that decouples the application processes from the hardware on which the processes run. Effectively, this decoupling creates a general-purpose software infrastructure spanning all the different compute resources on the system (Routing Engine CPUs, line card CPUs, and possibly others). Application processes (protocols, services, and so on) run on top of this infrastructure and communicate with each other by publishing and consuming (that is, subscribing to) state.

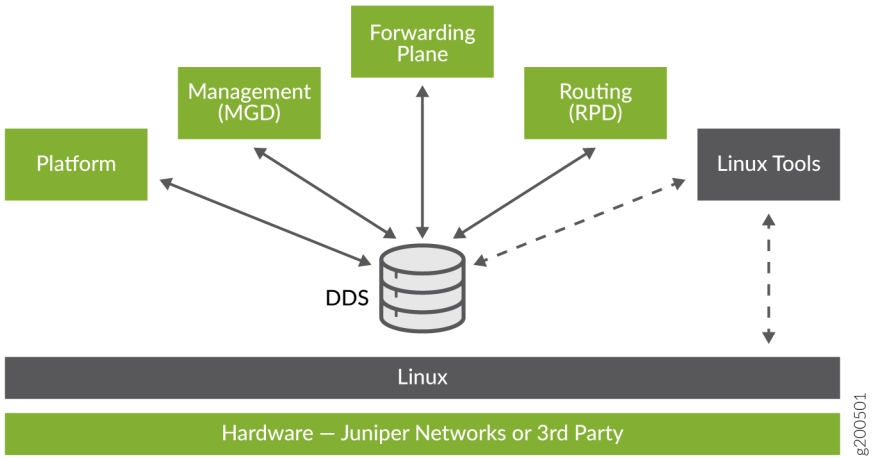
Integrated Database for State

State is the retained information or status about physical or logical entities that the system preserves and shares across the system, and supplies during restarts. State includes both operational and configuration state, including committed configuration, interface state, routes, and hardware state. In Junos OS Evolved, state can be held in a database called the Distributed Data Store (DDS).

The DDS does not interpret state. Its only job is to hold state received from subscribers and propagate state to consumers. It implements the publish-subscribe messaging pattern for communicating state between applications that are originators of a state to applications that are consumers of that state (see

Figure 1 on page 4). Each application publishes state to and subscribes to state from the DDS directly, making applications independent of each other.

Figure 1: Publish-Subscribe Model



Decoupling applications in this manner isolates the failure of one application from others. The failing application can restart using the last known state of the system held in the state database.

Modular Design

Junos OS Evolved is composed of components with well-defined interfaces. Applications can be individually restarted without requiring a system reboot. Restarted applications reload the state that is preserved in the DDS.

Secure Boot

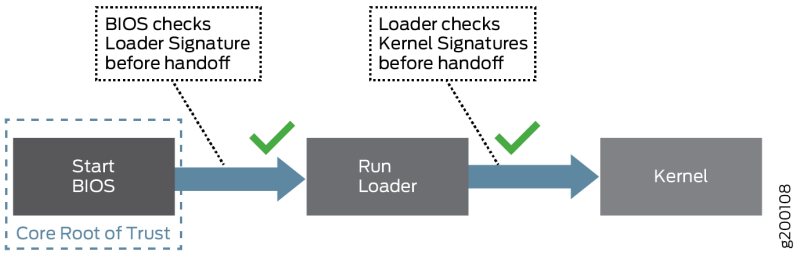
Secure Boot is a significant system security enhancement based on the UEFI standard (see www.uefi.org). It works by safeguarding the BIOS itself from tampering or modification and then maintaining that protection throughout the boot process.

The Secure Boot process begins with Secure Flash, which ensures that unauthorized changes cannot be made to the firmware. Authorized releases of Junos OS carry a digital signature produced by either Juniper Networks directly or one of its authorized partners. At each point of the boot-up process, each component verifies the next link is sound by checking the signature to ensure that the binaries have not been modified. The boot process cannot continue unless the signature is correct. This "chain of trust"

continues until the operating system takes control. In this way, overall system security is enhanced, increasing resistance to some firmware-based persistent threats.

Figure 1 shows a simplified version of this “chain of trust.”

Figure 2: Secure Boot Model



Secure Boot requires no actions on your part to implement. It is implemented on supported hardware by default.

For information on which Junos OS Evolved releases and hardware support Secure Boot, see Feature Explorer and enter **Secure Boot**.

Top Differences Between Junos OS Evolved and Junos OS

IN THIS SECTION

Although we've aligned Junos OS Evolved with Junos OS, there are some key differences to keep in mind when operating Junos OS Evolved. Junos OS Evolved is built on top of a Linux kernel, while Junos OS operates on the FreeBSD kernel. This and other fundamental differences in the design of Junos OS Evolved may be relevant in the management of your network. Read on to learn about the top differences between Junos OS Evolved and Junos OS.

System Differences

The concept of *system* in Junos OS Evolved is different from Junos OS. Junos OS uses a Routing Engine centric model, where *system* usually refers to a Routing Engine. However, Junos OS Evolved uses a *node*-based model, where *system* refers to all nodes, including Routing Engines, Flexible PIC Concentrators (FPCs), and more. In Junos OS Evolved, a *node* is any component that can run the Linux kernel and Junos OS Evolved applications, and all nodes are considered compute nodes.

Operational Impact

In Junos OS Evolved you can perform many actions on a per-node basis. You can use CLI commands to view information and request operations on individual nodes.

Relevant CLI Commands

- `show system nodes` — View a list of all nodes in the system.
- `show node ( reboot | statistics ) node-name` — View information about a specific node.
- `show system applications <node node-name>` — Display application summary information for all nodes or a specific node.
- `show system core-dumps <node node-name>` — Show system core files for all nodes or a specific node.
- `show system errors active`—Use this command instead of the `show chassis errors active` command to view system error information.
- `show system processes <node node-name> <detail>` — Display process information for all nodes or a specific node.

- `show system storage node ( re0 | re1 | fpc0 | fpc1 | ...)` — View the free disk space for a specific node.
- `show version node ( all | node-name )` — Display software version information for all nodes or a specific node.
- `request node ( halt | offline | online | power-off/on | reboot ) node-name` — Request an operation on a specific node.
- `request system reboot` — In Junos OS Evolved this command will reboot all nodes.

Software Structure and Applications

Junos OS Evolved functions as a distributed Linux OS with processes running as self-contained applications. Every Junos OS Evolved process runs as an application. All Junos OS Evolved applications are managed by the `systemd` process using service units. Applications run as separate services, which provides fault isolation because you can restart an application separately without impacting other applications. Most applications publish and consume state, which is stored in a central database.

Operational Impact

In Junos OS Evolved, many high availability features are per-application rather than per-node. Some applications run a full-time backup for rapid failover, while other applications are restarted on a new node in the event of a failure.

Relevant CLI Commands

- `show system applications <node node-name>` — Display application summary information for all nodes or a specific node.
- `restart process` — In Junos OS this command restarts a specific process. In Junos OS Evolved the same command restarts a specific application (process) on the same node from which the command is issued.
- `request system application restart app application node node` — This command is specific to Junos OS Evolved and restarts a specific application on a specific node.

State Model

Junos OS Evolved uses a distributed state infrastructure. Applications publish or subscribe to state objects, which are stored in a state database called the Distributed Data Store (DDS) that is distributed across nodes. By comparison, Junos OS processes store state internally, exchanging state information and state changes with other processes through the kernel. The Junos OS Evolved state model is

asynchronous and eventually consistent at the transport layer with causal consistency at the application layer when accessing state. This means that if a process restarts in Junos OS Evolved, information is not lost because it can retrieve state information from the DDS.

Operational Impact

The Junos OS Evolved state model leads to faster performance because you don't have to wait for the slowest component to update. Applications read from and write to system state without waiting for every other process to first complete updates. If an application restarts, state is preserved and retrieved from the DDS by the new instance, even if the application is spawned on a different node.

Software Management

Each time you install a software image on Junos OS Evolved, the previous software image and configuration are preserved automatically. Junos OS Evolved stores software images in the **/soft** directory. Each version of the software is stored in a distinct area, thus ensuring that a software package installation does not affect the other software versions installed on the system. While Junos OS supports installing two software versions on the device, Junos OS Evolved supports storing as many software images as space allows. However, we recommend that you keep no more than five versions of software on the system.

During a successful installation, the installation package completely re-installs the existing software. It retains configuration files and similar information, such as secure shell and host keys, from the previous version. When you reboot the system after a software package installation, all the Routing Engines and FPCs in the system run the new version of the software.

Operational Impact

Junos OS Evolved ensures that all Routing Engines and FPCs in the system are running the same software version. When you install a software image on the primary Routing Engine, the system installs the new version of software on both Routing Engines, if the Routing Engines are online and part of the system. If you insert a Routing Engine that has a different software version into the system and you have not configured the `system auto-sw-sync enable` statement, the Routing Engine is kept outside the system, and the system generates a software mismatch alarm.

When you install a new software image, the previous software package is preserved in a separate area, and you can manually roll back to it if necessary. Junos OS Evolved enables you to roll back to an alternate image with either the current configuration file or with the configuration snapshot from when the alternate image was last running.

Relevant CLI Commands

- `show system software list` — On Junos OS Evolved, view the currently installed images on each node.

- `show system storage` — View available storage space. On Junos OS Evolved, the **/soft**, **/var**, and **/data** directories must have less than 90% capacity to install additional images.
- `request system software delete` — Clean up old images. Starting in Junos OS Evolved Release 20.1R1, use this command instead of the `request system storage cleanup` command to remove ISO images from the system.
- `request system snapshot` — Take a snapshot of the files currently used to run the device, and copy the files onto the alternate solid-state drive (SSD). The snapshot includes the complete contents of the **/soft**, **/config**, and **/root** directories, copies of user data, and content from the **/var** directory (except the **/var/core**, **/var/external**, **/var/log**, and **/var/tmp** directories).
- `request system software rollback reboot <`*package-name*`> <with-old-snapshot-config>` — Roll back all Routing Engines and FPCs to another software version and reboot. Include the `with-old-snapshot-config` option to use the saved configuration that corresponds to the rollback software image.
- `request system software sync ( all-versions | current | rollback )` — Synchronize software and configurations from the primary Routing Engine to the other nodes and reboot the other nodes.
- `set system auto-sw-sync enable` — Automatically synchronize the software and the configuration from the primary Routing Engine to a newly added Routing Engine and reboot, when the newly added Routing Engine has a different software version from the rest of the system.

Management Interfaces

On Junos OS Evolved, management interfaces are renamed to accommodate more than one management port per Routing Engine node.

Operational Impact

Management interfaces in Junos OS Evolved do not use the same names as Junos OS (`fxp0`, `em0`, `me0`). Instead, the Junos OS Evolved management interface name format is *device-name*:*type-port*. For example: `re0:mgmt-0`, `re0:mgmt-1`, `re1:mgmt-0`, `re1:mgmt-1`.

The `show interfaces` output displays the status of all interfaces, including management Ethernet interfaces from both Routing Engines of a dual Routing Engine system.

System Hostnames

In Junos OS Evolved, system hostnames are appended with a corresponding Routing Engine number such as `-re0` or `-re1`.

Operational Impact

In Junos OS Evolved, when you specify the `host-name` statement, the current Routing Engine name is appended to the *hostname* you specify. For example, on Routing Engine 0, `set system host-name` *`my-host`* sets the hostname to `my-host-re0`. You can also use the `%s` character to designate where to substitute the Routing Engine name. For example, on Routing Engine 1, `set system host-name` *`%s_my_host`* sets the hostname to `re1_my-host` .

Relevant CLI Commands

- `set system host-name` *`hostname`*

Routing Engine Firewall Filters

In Junos OS, to control the flow of local packets between the physical interfaces and the Routing Engine, you can apply stateless firewall filters to the input or output of the loopback interface. The loopback interface (lo0) is the interface to the Routing Engine and carries no data packets. In Junos OS, filters applied to the loopback interface apply to both network control traffic and management traffic.

Junos OS Evolved, on the other hand, supports two different filters to control the flow of local packets: one for network control traffic (loopback traffic) and one for management traffic. Thus, filters applied to the loopback interface apply only to network control traffic. You can also apply filters separately to the management interface, which enables you to configure a stricter filter on management traffic.

Operational Impact

In Junos OS Evolved, firewall filters applied to the loopback interface apply only to network control traffic. You must explicitly apply firewall filters to the management interface to filter management traffic. In Junos OS Evolved, management filtering uses Routing Engine filters based on Netfilter, a framework that the Linux kernel provides. As a result, only certain matches and actions are supported. Table 1 on page 10 outlines the Junos OS Evolved filter application.

Table 1: Filter Application for Network Control Traffic and Management Traffic

Interface	Filter Direction	Junos OS Evolved Behavior
lo0	input	Filters are applied at the Packet Forwarding Engine and applied on network ingress traffic.

Table 1: Filter Application for Network Control Traffic and Management Traffic *(Continued)*

Interface	Filter Direction	Junos OS Evolved Behavior
	output	Filters are applied at the Routing Engine and applied on network egress traffic.
management	input	Filters are applied at the Routing Engine and applied on management ingress traffic.
	output	Filters are applied at the Routing Engine and applied on management egress traffic.

Junos OS Evolved Network Stack

Junos OS Evolved runs on native Linux. There are some differences between the way Linux displays requested network topology information, such as interface and route data, and the way Junos OS displays this information. The Junos OS Evolved CLI is designed to overcome these differences. Thus, we recommend that you use CLI commands rather than shell commands for any network operations, particularly for operations that require specifying a routing instance.

If you must perform operations in the Linux shell when using Junos OS Evolved, you need to know about the following routing instances, also known as virtual routing and forwarding instances (VRFs):

- `default`—Handles both WAN and management traffic by default, unless you configure the `mgmt_junos` routing instance.
- `mgmt_junos`—When you configure this routing instance, it puts the management port into its own routing instance, which separates the management traffic from the WAN traffic for the Routing Engine.
- `iri`—Handles control plane traffic (internode communication). In the Junos OS Evolved CLI, this is equivalent to the `__juniper_private1__` routing instance.

Operational Impact

In the Junos OS Evolved shell, you can use the `chvrf` (change VRF) utility to execute a command in the context of a specific routing instance, or VRF. For example:

```
[vrf:none] user@host:~$ chvrf -JU default ping 172.16.1.1
[vrf:none] user@host:~$ chvrf -JU iri ping fpc1
[vrf:none] user@host:~$ chvrf -JU mgmt_junos ping 198.51.100.1
[vrf:none] user@host:~$ chvrf -JU iri ssh re1
```

System Logging

In Junos OS Evolved, each node has the standard `journalctl` tool, which is an interface to retrieve and filter the system journal. System log messages are parsed from the system journal. The `relay-eventd` process runs on all nodes and retrieves events (based on the syslog configuration) from the system journal as well as error messages from the different applications and forwards them to the `master-eventd` process. The `master-eventd` process runs on the primary Routing Engine and writes the log messages and errors to disk.

Use the System Log Explorer application to view or compare system log messages in different releases.

Operational Impact

In Junos OS Evolved there is no `messages` file on the backup Routing Engine. All backup Routing Engine logs are in the `messages` file on the primary Routing Engine node.

System Log Message Format

By default, Junos OS Evolved appends the node name to the hostname in system log messages; Junos OS does not. This action keeps Junos OS Evolved system log messages compliant with RFC5424. However, some monitoring systems may not identify a Junos OS Evolved hostname correctly, because the hostname-node name combination does not match any hostnames in the inventory of hostnames.

Operational Impact

If your monitoring system is not identifying Junos OS Evolved hostnames correctly, you should issue the `set system syslog alternate-format` configuration mode command. This command changes the format of the Junos OS Evolved system log messages. The node name is prepended to the process name in the message rather than appended to the hostname, thereby allowing the monitoring system to identify the hostname correctly.

Tracing Architecture

Junos OS Evolved uses a new tracing architecture. All running applications create trace information, with multiple instances of the same application having their own trace information. The Junos OS Evolved `trace-relay` and `trace-writer` applications coordinate tracing information. The `trace-relay` application runs on local nodes and shares a memory buffer with each application. When a Junos OS Evolved application writes to memory, the `trace-relay` application reads the data directly from memory and sends it to the `trace-writer` applications. A `trace-writer` application runs on each Routing Engine node. It receives the trace information sent from the `trace-relay` applications and writes it to the appropriate file in Common Trace Format (CTF).

NOTE: For general monitoring and troubleshooting of devices running Junos OS or Junos OS Evolved, we recommend using standard tools such as CLI `show` commands, system log messages, SNMP, and telemetry data. You should avoid using trace messages for general debugging purposes and long-term solutions because they are subject to change without notice.

Operational Impact

In Junos OS, you enable tracing operations by configuring the `traceoptions` statement at the specific hierarchy level you want to trace. Junos OS Evolved, on the other hand, uses an application-based model, and thus trace messages are logged, viewed, and configured by application. As a result, Junos OS Evolved does not support the `traceoptions` statement at many of the hierarchy levels that Junos OS supports. However, some hierarchy levels, such as those under `[edit protocols]`, still require configuring the `traceoptions` statement to enable trace messages.

Although Junos OS disables global tracing operations for many hierarchy levels by default, some processes log trace messages by default for important events. In contrast, all running applications on Junos OS Evolved create trace information at the `info` level by default.

In Junos OS Evolved, you do not view trace files directly, and you should never add, edit, or remove trace files under the **/var/log/traces** directory because this can corrupt the traces. Instead, you use the `show trace application` *`application-name`* `node` *`node-name`* command to read and decode trace messages stored in the trace files.

Relevant CLI Commands

- `show trace application` *`application-name`* `node` *`node-name`* — Read and decode trace files.
- `clear trace` — Manually clean up trace files.
- `set system trace` *`application`* — Modify trace message configurations at the application level.

How Junos OS Evolved Differs from Junos OS

IN THIS SECTION

In many ways, Junos OS Evolved is the same as Junos OS: Key applications such as the routing, bridging, and management software are the same in both and management plane interfaces and APIs, such as CLI, NETCONF, JET, JTI, AFI, and underlying data models, remain highly consistent. In both Junos OS and Junos OS Evolved, you can use remote authentication methods through the console port. There are, however, some differences in behavior, the CLI syntax, and CLI and XML output. These differences are indicated throughout the Junos OS documentation. However, this section outlines the differences in one place, for your convenience. If applicable, a link takes you to the place in the Junos OS documentation that covers the item.

For a more detailed overview of the top differences between Junos OS and Junos OS Evolved, see "Top Differences Between Junos OS Evolved and Junos OS" on page 5.

Behavioral Differences Between Junos OS Evolved and Junos OS

Behavioral differences between Junos OS Evolved and Junos OS are ways that the two operating systems act differently in certain circumstances. See Table 2 on page 14.

Table 2: How Junos OS Evolved Behavior Differs from Junos OS

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
Access and Authentication		

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
In Junos OS Evolved Release 20.4R1 and earlier releases, when you do not configure the password authentication method and the remote authentication servers reject the authentication request, the device still attempts local password authentication. Remote authentication methods are supported through the console port in 23.2R2-EVO and from 23.4R1-EVO onwards, and unsupported before 23.2R2-EVO and 23.3 EVO.	In Junos OS, when you do not configure the password authentication method and the remote authentication servers reject the authentication request, the request ends with the rejection.	*Authentication Order for LDAPS, RADIUS, TACACS+, and Local Password*
Junos OS Evolved does not support the following options at the `[edit system login retry-options]` hierarchy level: • `backoff-threshold` • `backoff-factor` • `maximum-time` • `minimum-time` • `tries-before-disconnect`	In Junos OS, the `backoff-threshold`, `backoff-factorlockout-period`, `maximum-time`, `minimum-time`, and `tries-before-disconnect` options are supported at `[edit system login retry-options]` hierarchy.	*retry-options*
Interfaces		
The management interface name format changed to accommodate more than one management port per Routing Engine node. The names are re0:mgmt-0/re0:mgmt-1 and re1:mgmt-0/re1:mgmt-1. Both the management interfaces are configurable and displayed.	The management interface name that you use depends on the type of device that you are setting up. Some devices use me0, some use fxp0, and some use em0.	*Understanding Management Ethernet Interfaces*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
In an untagged link aggregation group (LAG), child logical interface (IFL) members are created. Requests are made per child IFL member. The results are aggregated and displayed in the CLI. In a VLAN-tagged LAG, extra child IFLs are not created as part of the aggregated Ethernet bundle. Link IFL statistics and marker statistics for child IFLs are not displayed.	Child IFL members are created in untagged and VLAN-tagged LAGs. Requests are made per child IFL member. The results are aggregated and displayed in the CLI.	*Aggregated Ethernet Interfaces*
When a new interface is added as a member to an aggregated Ethernet bundle, the new member interface flaps: the physical interface is deleted as a regular interface and then added back in as an aggregated Ethernet member and the statistics are reset.	When a new interface is added as a member to an aggregated Ethernet bundle, that new interface is not first deleted as a lone interface and then added, but everything below it is. Because the interface is not deleted, it keeps all the statistics and other history associated with it.	*Aggregated Ethernet Interfaces* and *Overview*
Junos OS Evolved does not impose a limit on the maximum number of member (or child) interfaces in an aggregated interface. However, platform limits still apply.	Junos OS imposes a limit of 64 member (or child) interfaces in an aggregated interface.	*Aggregated Ethernet Interfaces* and *Overview*
In Junos OS Evolved, when you configure a parent interface for Aggregated Ethernet with the [`set interfaces` *`interface-name`* `ether-options 802.3ad` *`ae-name`*] statement, any secondary (child) interface configurations made from the [`edit interfaces` *`interface-name`*] hierarchy will not take effect until the interface has been committed to the named Aggregated Ethernet (ae) interface. This applies to both `ether-options` and `gigether-options`.	In Junos OS, configurations for aggregated Ethernet interfaces and non-aggregated Ethernet interfaces at the [`edit interfaces` *`interface`*] hierarchy are independent of configurations at the [`edit interfaces` *`interface`* `ether-options`] and [`edit interfaces` *`interface`* `gigether-options`] hierarchies and will be effective when applied.	*ether-options*, *gigether-options*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
In Junos OS Evolved, when you add a duplicate IP address or prefix to an existing configuration, the operating system will error out and prevent a commit. Instead, you must first delete the existing prefix and commit the new configuration. After you have done that, you can add the duplicate prefixes and commit.	In Junos OS, you can add a duplicate IP address or prefix to an existing configuration without having your commit blocked.	*prefix-list*
Starting from Junos OS Evolved Release 21.1R1, we changed the default forward error correction (FEC) for 25-Gigabit and 50-Gigabit interfaces to FEC91 from FEC74 because FEC91 has better performance. FEC mode is assigned by default. You must disable FEC mode if you do not want it assigned by default.	In Junos OS, the default FEC for 25-Gigabit and 50-Gigabit interfaces is FEC74. You can configure FEC clauses CL74 on 25-Gigabit and 50-Gigabit interfaces, and CL91 on 100-Gigabit interfaces. Since the FEC clauses are applied by default on these interfaces, you must disable the FEC clauses if you do not want to apply them.	*fec (ether)*
High Availability		
On PTX10004 and PTX10008 platforms running Junos OS Evolved, graceful Routing Engine switchover (GRES) is enabled by default and cannot be disabled.	GRES is disabled by default.	*Understand Graceful Routing Engine Switchover for Junos OS Evolved*
In Junos OS Evolved, the output for `show system switchover` displays entries for `Object database` and `Applications' ready state`. Junos OS Evolved uses an application-based architecture.	Junos OS output for `show system switchover` displays an entry for `Kernel database`.	*show system switchover*
(Only for QFX5220-32CD switches) In-Service Software Upgrade (ISSU) is performed by using the `request system software add restart` command.	ISSU is performed by using the `request system software in-service-upgrade` command.	*request system software add restart*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
Junos XML API and Scripting		
You must set up the password-less login between two devices to use the `jcs:open` extension function in SLAX or XSLT scripts to open a connection to the local or remote device.	You are not limited to password-less login. Junos OS supports both a supplied password and interactive password, for example, to execute RPCs on remote devices.	*open() Function (SLAX and XSLT)*
The eventd process does not give any warning message if there are duplicate event policies. Instead eventd accepts the event policy on a first-come, first-served basis.	The eventd process gives a warning message if you try to create duplicate event policies.	*Event Policies and Event Notifications Overview*
For op scripts run with the `max-datasize` configuration statement configured for the minimum memory, an error occurs. In Junos OS Evolved, the error is "Out of memory."	For op scripts run with the `max-datasize` configuration statement configured for the minimum memory, an error occurs. In Junos OS, the error is "Memory allocation failed."	*max-datasize*
If you execute the `sysctl()` extension function in a script and request an invalid sysctl variable name, Junos OS Evolved generates a `sysctl error: No such file or directory` error.	If you execute the `sysctl()` extension function in a script and request an invalid sysctl variable name, Junos OS does not generate any error.	*Using the sysctl() Extension Function on Junos Devices*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
Junos OS Evolved collects the trace data for all scripts in trace files that correspond to the `cscript` application instead of in separate log files. The trace log includes data for commit, event, op, and SNMP scripts; YANG action and translation scripts; and Juniper Extension Toolkit scripts. You can view the trace data by issuing the `show trace application cscript` command. Junos OS Evolved captures trace data for all applications by default. You can modify the default trace settings for all scripts by configuring statements at the `[edit system trace application cscript]` hierarchy.	Junos OS stores the trace data for each type of script in a different log file in the **/var/log** directory. To view a particular log, issue the **show log *logname*** command, where *logname* is the default or user-configured filename, for example, **cscript.log**, **escript.log**, **op-script.log**, and so on. On Junos OS, tracing operations for scripts, by default, log important events. You can modify the default trace settings by configuring the `traceoptions` statement at the hierarchy level for that script type.	*Trace Script Processing on Devices Running Junos OS Evolved*
Messaging		
TIP: You can compare syslog messages in a Junos OS release to a Junos OS Evolved release using the System Log Explorer.		System Log Explorer
The **messages** file located under **/var/log** is only written on the primary Routing Engine. Backup Routing Engine messages are found in the **messages** file on the primary Routing Engine.	The **messages** file is written on both the primary Routing Engine and the backup Routing Engine.	*Displaying System Log Files*
Junos OS Evolved appends the node name to the hostname in system log messages. As of Junos OS Evolved Release 20.4R2, you can configure the `alternate-format` statement at the `[edit system syslog]` hierarchy level to attach the node name to the process name instead of the hostname. This alternate format allows monitoring systems to identify the hostname correctly.	Junos OS does not.	*Overview of System Logging*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
Starting in Junos OS Evolved Release 20.1R1 and 19.4R2, if you are sending syslog messages to a remote host that is identified by its IP address at the `[edit system syslog host ip-address]` hierarchy, you only need to configure the `management-instance` statement to use the mgmt_junos routing instance. You do not need to configure the mgmt_junos routing instance at the `[edit system syslog host ip-address routing-instance]` hierarchy.	Configure the mgmt_junos routing instance at the `[edit system syslog host ip-address routing-instance]` hierarchy if you want to send syslog messages to a remote host that is identified by its IP address at the `[edit system syslog host ip-address]` hierarchy.	*routing-instance*
When a regular expression returns empty pattern matches, there is no error message.	When a regular expression returns empty pattern matches, you get the following error: regex error: empty (sub)expression	*Junos System Log Regular Expression Operators for the match Statement*
Junos Evolved does not support a `/var/log/inventory` file.	In Junos the `/var/log/inventory` log file stores hardware serial numbers. For Junos Evolved use the CLI `show chassis hardware` operational mode command to display hardware inventory.	**NOTE**: The `/var/log/inventory` logfile is deprecated functionality in Junos.
Routing Policy and Firewall Filters		
When you issue the `show firewall filter ?` command, the names of the firewall filters are listed. The names of the Flowspec filters are not listed. To see the names of the configured Flowspec filters, use the `show firewall application routing` command.	When you issue the `show firewall filter ?` command, you see not only the names of the firewall filters listed but also the names of the configured Flowspec filters. The Flowspec filters show up inside underscores.	*show firewall*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
Firewall filters applied to the loopback interface apply only to network control traffic. You must explicitly apply firewall filters to the management interface to filter management traffic.	Firewall filters applied to the loopback interface apply to both network control traffic and management traffic.	*Stateless Firewall Filter Overview*
In Junos OS Evolved, if a match action term on your filter configuration fails on commit, the entire filter is not applied. This happens when a term you configured is not supported on your device.	In Junos OS, if a match action term on your filter configuration fails on commit, the remainder of the filter is applied.	*Firewall Filters Overview*
When you use an IPv6 filter with packet length matching, the match parameter only considers the TCP header length and the data length. To configure the statement `set firewall family inet6 filter` *`filter-name`* `term` *`term-name`* `from packet-length` *`packet-length`* correctly, you need to specify the packet-length parameter without the IPv6 header size included.	When you use an IPv6 filter with packet length matching, the match length parameter includes the IPv6 header size.	*Parameterized Filter Match Conditions for IPv6 Traffic*
In a filter with icmp match conditions, Junos OS Evolved supports configuration of a single icmp-type value along with an icmp-code value. Junos OS Evolved supports configuration of multiple icmp-type values only when an icmp-code value is **not** specified.	Junos OS supports a configuration that contains multiple icmp-type values and an icmp-code value.	*Overview of Firewall Filters (OCX Series)*
Software Installation and Upgrade		
Multiple releases of the software can be installed on the device simultaneously as long as there is space. If there is no more space, you must delete an older image of the software before installing the new one.	Only two versions of the software can be installed on the device: the current version and the previous version.	*Software Installation and Upgrade Overview (Junos OS Evolved)*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
The `request system snapshot` command takes a snapshot of the files currently used to run the device and copies all of these files onto an alternate solid-state drive. The snapshot includes the complete contents of the **/soft**, **/config**, and `/root` directories, copies of user data, and content from the **/var** directory (except the `/var/core`, `/var/external`, `/var/log`, and `/var/tmp` directories).	The `request system snapshot` command takes a snapshot of the software and configuration and saves it to the **/packages/sets** directory.	*request system snapshot (Junos OS Evolved)* *Software Installation and Upgrade Overview (Junos OS Evolved)*
The `request system storage cleanup` command does not remove Junos OS Evolved images from the device after Release 20.1R1. It removes all core files, log files from **/var/log/**, and all **/var/log/*** files. To remove old images from the device, use the `request system software delete` command.	The `request system storage cleanup` command removes all Junos OS images from the device, including old images and the currently installed image, as well as core files from **/var/crash**, log files from **/var/log/**, and certain other files from **/var/tmp**.	*request system storage cleanup (Junos OS Evolved)*
During the validation phase of a software upgrade, Junos OS Evolved installs the image in a temporary storage location until validation is complete. After validation is complete, Junos OS Evolved will attempt to uninstall the image and display a status message.	Junos OS installs the software upgrade image in a standard storage location. No message is displayed following image validation.	*Validate the Configuration against the Installation Image*
After you add a new software image, you must reboot the system to run the new software. If you have added the software image but have not yet rebooted, you can issue the `request system software delete` *`package-name`* command to remove the newly added package and cancel the installation.	If you have completed the installation of the software image but have not yet rebooted, issue the `request system software rollback` command to return to the original software installation package.	*request system software delete (Junos OS Evolved)*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
Junos OS Evolved supports one system log file that contains all system log messages for the Zero Touch Provisioning (ZTP) process: **/var/log/ztp.log**.	Junos OS ZTP system log messages are spread out over several system log files: • **/var/log/dhcp_logfile** • **/var/log/event-script.log** • **/var/log/image_load_log** • **/var/log/messages** • **/var/log/op-script.log** • **/var/log/script_output**	*Zero Touch Provisioning for Junos OS Evolved*
ZTP for Junos OS Evolved supports WAN interfaces as well as the management interface for Routing Engine 0. ZTP dynamically detects the port speed of WAN interfaces and uses this information to create ZTP server ports with the same speed.	ZTP for Junos OS supports management interfaces.	*Zero Touch Provisioning for Junos OS Evolved*
For ZTP on Junos OS Evolved, if downloading a file fails, ZTP clears the DHCP client binding on that interface and restarts the state machine on other interfaces. If installation fails for any reason, ZTP retries on other interfaces.	If downloading a file fails on Junos OS, the DHCP client attempts to fetch files from the DHCP server for up to six times, with ten to fifteen seconds elapsing between attempts. If the download fails, ZTP stops. ZTP then clears the DHCP client bindings and restarts the state machine on the DHCP-configured interfaces. If installation fails for any reason, ZTP restarts.	*Zero Touch Provisioning for Junos OS Evolved*
ZTP for Junos OS Evolved accepts unsigned scripts in DHCP option 43, suboption 1.	ZTP for Junos OS with Enhanced Automation accepts unsigned scripts in DHCP option 43, suboption 1; otherwise, scripts must be signed.	*Zero Touch Provisioning for Junos OS Evolved*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
ZTP for Junos OS Evolved uses DHCP option 43, suboption 5 for the IP address of the FTP server and does not use option 8.	ZTP for Junos OS uses DHCP option 43, suboption 5 for the HTTP port and uses suboption 8 for the IP address of the HTTP proxy server.	*Zero Touch Provisioning for Junos OS Evolved*
ZTP for Junos OS Evolved does not change the default route.	For Junos OS, after the lists of bound and unbound client interfaces are created, and a DHCP client gets selected for ZTP activity, any existing default route is deleted and the DHCP client interface that was selected adds a new default route. To add a new default route, only one ZTP instance can be active.	*Zero Touch Provisioning for Junos OS Evolved*
System Management		
In Junos OS Evolved, hostnames cannot be configured with an underscore or special characters as part of the hostname. Any other combination of alphabetic characters, numbers, and dashes/hyphens can be used. Hostnames cannot start with a dash/hyphen. You can configure the hostname at the `[edit system]` hierarchy level.	In Junos OS, hostnames can be configured with any combination of alphabetic characters, numbers, dashes, and underscores. Special Characters cannot be used. You can configure the hostname at the `[edit system]` hierarchy level.	Hostnames Overview
In Junos OS Evolved, the `request system reboot` command reboots the entire system (all nodes) at once. To reboot a specific node, use the `request node reboot` command.	In Junos OS, by default, the `request system reboot` command reboots only the Routing Engine to which you are connected.	*request system reboot (Junos OS Evolved)*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
After rebooting Junos OS Evolved, the system initializes time from the hardware clock. The ntpd command with the -g option runs to adjust the time if the initial offset is large (greater than 1000 seconds). In addition, the system synchronizes time with a valid NTP server.	When you boot Junos OS, the system issues an ntpdate request, which polls a network server to determine the local date and time. You need to configure a server that the system can use to determine the time when the system boots. If an NTP boot server was configured when the system boots, the system immediately synchronizes with the NTP boot server. Synchronization occurs even when the NTP process is explicitly disabled or when the time difference between the client and the NTP boot server exceeds the threshold value of 1000 seconds.	Synchronize and Coordinate Time Distribution Using NTP
Troubleshooting		
Junos OS Evolved uses a new tracing infrastructure. For Junos OS Evolved, trace data from all applications on all nodes is collected on the Routing Engine. You use the `show trace application` *`application-name`* `node` *`node-name`* command to read and decode trace messages stored in the trace files. You can modify trace options for specific applications at the `[edit system trace application]` hierarchy level. However, a few applications still use the `traceoptions` statement.	Configure `traceoptions` to enable trace logging for a specific process or protocol.	*trace*
For Junos OS Evolved, a core file created during early bootup is stored in **/var/core/re**. However, a core file created later in the bootup, for example, after the Routing Engine slot number can be determined, is stored in **/var/core/re0** or **/var/core/re1**. The command `show system core-dumps` shows all cores generated.	For Junos OS, core files are stored in **/var/crash** or **/var/tmp**.	*show system core dumps (Junos OS Evolved)*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation
User Interface		
Junos OS Evolved does not support the `virtual-memory-mapping` option.	The `virtual-memory-mapping` option of the `configuration-database` statement defines parameters for using virtual memory mapping for the configuration database on a per-process basis.	*configuration-database*
The `show system reboot` command has options to Execute this command or Pipe through a command.	The show system reboot command has options to Execute this command, Show halt or reboot requests on both Routing Engines, or Pipe through a command.	*show system reboot*
In Junos OS Evolved, enabling the command `set system switchover-on-routing-crash` causes a Routing Engine mastership switchover to occur only on rpd crashes and any uncontrolled rpd exits from outside the CLI (like `kill -9 rpi_pid` from the Linux shell). Commands like `restart routing` within the CLI do NOT trigger a switchover.	When NSR is configured and the command `edit system switchover-on-routing-crash` is enabled, Junos OS will immediately switch to the backup Routing Engine when rpd crashes.	*switchover-on-routing-crash*
In Junos OS Evolved, when `set system processes routing failover other-routing-engine` is configured, repeating commands like `restart routing` and `restart routing immediately`within the CLI will not cause a Routing Engine mastership switchover when entered more than 4 times in 30 seconds. However, repeated uncontrolled exits (more than 3 times in 5 minutes) from outside the CLI (like `rpd crash -9` and `rpd kill -15`) from the Linux shell will cause rpd to fail and trigger a switchover. If this happens, you must restart the app using the command line interface.	Junos OS triggers a switchover when `edit system processes routing failover other-routing-engine` is configured and certain commands such as `restart routing`and `restart routing immediately` are used many times in short succession.	*failover (System Process)*

Table 2: How Junos OS Evolved Behavior Differs from Junos OS *(Continued)*

Junos OS Evolved Behavior	Junos OS Behavior	Link to Documentation

The menu used for root password recovery is the GRUB menu.
 	
`*Primary ptx-fixed-19.1-16`
`Primary [Recover password]`
`Primary-Rollback ptx-fixed-19.1-15`
`Primary-Rollback [Recover password]`
	The menu used for root password recovery is the Junos Main Menu (the Recovery mode option).	*Recovering Root Password*

The `show system firmware` command displays information based on the accessibility of the device, not the FRU state. The firmware information is cached so, even if the FRU is in a fault condition, the status from the `show system firmware` command appears as `OK`. The fault is visible with the commands `show chassis alarms`, `show chassis fpc`, and so on.	When the FRU is offline, the cached firmware information of the FRU is not available to view.	*show system firmware*

New CLI Statements and Commands (Junos OS Evolved)

The changes in infrastructure between Junos OS and Junos OS Evolved sometimes require different CLI configuration statements and operational commands. For more on these new statements and commands, see Table 3 on page 27.

Table 3: New CLI Statements and Commands (Junos OS Evolved)

Statement or Command	Description	Link
New Statements		

Table 3: New CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description	Link
`[edit chassis fabric event reachability-fault degraded error-threshold` *`percentage`*`]`	You can configure how much fabric degradation is allowed before automatic recovery actions are taken by Junos OS Evolved.	*reachability-fault*
`[edit system extensions extension-service application file` *`filename`* `interpreter (bash | python | python3)]`	You can use the configuration statement `interpreter` to specify that a device running Junos OS Evolved run a daemonized on-device JET application using Bash, Python 2, or Python 3. Starting in Junos OS Evolved Release 22.3R1, Python 2.7 is no longer supported. The `python` statement is deprecated. Use the `python3` statement instead.	*file*
`[edit services monitoring twamp]`	You can configure the TWAMP monitoring service on devices running Junos OS Evolved by using the hierarchy level `[edit services monitoring twamp]`. This service sends out probes to measure network performance. The support for this service is limited to the following: • IPv4 and IPv6 traffic (including link-local addresses) for control sessions and test sessions • Control session status and statistics • Test session operational management status and history • Test session probe generation and reception, as well as reflection • Timestamps set by the Routing Engine or the Packet Forwarding Engine • Error reporting through system log messages and SNMP traps only • Unauthenticated mode only	*Understanding Two-Way Active Measurement Protocol on Routers* and *twamp*

Table 3: New CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description	Link
`[edit security host-vpn]`	Junos OS Evolved supports host IPsec in the control plane only (that is, IPsec between the router and external management devices), which is not available in Junos OS. These statements configure a host-to-host VPN type of IPsec connection. Use the `connections`, `ike-log`, and `ike-secrets` statements at the `[edit security host-vpn]` hierarchy level to configure IKE and IPsec values.	*Overview of IPsec* and *host-vpn*
`[edit security host-vpn connections]`	You can configure the additional algorithms `aes256-sha384-modp3072` and `aes256-gcm128-modp3072` at each of the following hierarchy levels: • `[edit security host-vpn connections` *`parent-connection-name`* `ike-proposal]` • `[edit security host-vpn connections` *`parent-connection-name`* `children` *`child-connection-name`* `esp-proposal]`	*connections (Host VPN)* and *children*
`[edit security host-vpn connections children` *`child-name`*`]`	Statements at this hierarchy level include `local-traffic-selector`, and `remote-traffic-selector`.	*children*
`[edit security host-vpn connections dpd-delay]`	Statement to support dead peer detection. The dead peer detection delay sends keepalives to find out if a peer has gone dead.	*connections (Host VPN)*
`[edit security host-vpn remote]`	Configure identity details for authenticating the remote device during IKE negotiations.	*remote (Host VPN)*
`[edit system auto-sw-sync]`	Automatically copy over all the images (software and configuration) from the primary Routing Engine of the system to the new Routing Engine and reboot the new Routing Engine so it runs the same software version and configuration as the primary Routing Engine.	*auto-sw-sync*

Table 3: New CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description	Link
`[edit system configuration-database extend-size]`	Increase the memory space available for the configuration database. **NOTE**: In some releases prior to Junos OS Evolved Release 22.1R1, the extend-size statement is available in the CLI and you can configure and commit it, but it has no operational effect.	*configuration-database*
[edit system log alternate-format]	Attach the node name to the process name instead of the hostname. This alternate format allows monitoring systems to identify the hostname correctly.	*syslog*
`[edit system trace application]`	For Junos OS Evolved, trace data from all applications on all nodes is collected on the Routing Engine. See "Top Differences Between Junos OS Evolved and Junos OS" on page 13 for information about tracing architecture. See also the `clear trace` and `show trace` commands listed in the New Commands section of this table.	*trace*
New Commands		
`clear node reboot`	Remove all pending node halt, reboot, and power-off requests.	*clear node reboot*
`clear security host-vpn security-associations`	Clear host IPsec security association information. See also `[edit security host-vpn]` in the New Statements section of this table.	*clear security host-vpn security-associations*
`clear services monitoring twamp server control-connection`	Clear connections established between the Two-Way Active Measurement Protocol (TWAMP) server and control clients.	*clear services monitoring twamp server control-connection*

Table 3: New CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description	Link
`clear trace`	Junos OS Evolved uses a new tracing infrastructure. This command deletes the trace data stored on the Routing Engine, enabling you to remove inactive tracing sessions. See also `[edit system trace application]` in the New Statements section of this table.	*clear trace*
`request node (halt | offline | online | power-off/on | reboot)` *node-name*	Request an operation on a specific node.	*request node halt (Junos OS Evolved)* *request node (offline | online) (Junos OS Evolved)* *request node power-off (Junos OS Evolved)* *request node power-on (Junos OS Evolved)* *request node reboot (re0 | re1) (Junos OS Evolved)*
`request services monitoring twamp client`	Start or stop a Two-Way Active Measurement Protocol (TWAMP) session.	*request services monitoring twamp client*
`request system application restart`	Stop and then start (restart) a specific process (for example, cmdd) on the node you specify.	*request system application (Junos OS Evolved)*
`request system debug-info`	Collect debug information from Junos OS Evolved, such as logs. The logs are stored in the **/var/tmp/debug_collector_*timestamp*** directory. Use the `node` option to collect information from a specific node.	*request system debug-info*

Table 3: New CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description	Link
`request system software sync (all-versions | current | rollback)`	Synchronize software and configurations from the primary Routing Engine to the other nodes and reboot the other nodes.	*request system software sync*
`request system software validate restart`	The command performs a dry run of the `request system software add restart` command and displays the ISSU impact of the new restart option. See *request system software add (Junos OS Evolved)* for more on the `restart` option.	*request system software validate (Junos OS Evolved)*
`restart app-name`	The following message is logged when you use the `restart` command: `App restarting <app name>. Related apps that may be impacted - <related-app name>.`	*restart (Junos OS Evolved)*
`show chassis routing-engine hard-disk-test`	Display the health of the hard disk with the `hard-disk-test` option. Use `disk /dev/disk-name status` argument to display the status of a particular disk.	*show chassis routing-engine*
`show node reboot`	Display any pending halt, reboot, or power-off requests on a node.	*show node reboot*
`show node statistics`	Display the network statistics of a node.	*show node statistics*
`show security host-vpn security-associations`	Display host IPsec security association information for a specific security association or for all connections. See also `[edit security host-vpn]` in the New Statements section of this table.	*show security host-vpn security-associations*
`show security host-vpn version`	Display the version of IPsec being used in the system.	*show security host-vpn version*

Table 3: New CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description	Link
`show services monitoring rpm history-results`	Display the results stored for the specified real-time performance monitoring (RPM) probes.	*show services monitoring rpm history-results*
`show services monitoring rpm probe-results`	Display the results of the most recent real-time performance monitoring (RPM) probes.	*show services monitoring rpm probe-results*
`show services monitoring twamp client history-results`	Display standard information about the results of the last 50 probes for a Two-Way Active Measurement Protocol (TWAMP) control connection.	*show services monitoring twamp client history-results*
`show services monitoring twamp client probe-results`	Display the results of the most recent Two-Way Active Measurement Protocol (TWAMP) probes.	*show services monitoring twamp client probe-results*
`show services monitoring twamp client control-info`	Display information about the control connections established between the Two-Way Active Measurement Protocol (TWAMP) server and control clients.	*show services monitoring twamp client control-info*
`show services monitoring twamp client test-info`	Display information about the test sessions established between the Two-Way Active Measurement Protocol (TWAMP) server and control clients.	*show services monitoring twamp client test-info*
`show services monitoring twamp server control-info`	Display information about the control connections established between the Two-Way Active Measurement Protocol (TWAMP) server and control clients for managed servers.	*show services monitoring twamp server control-info*
`show services monitoring twamp server test-info`	Display information about the test sessions established between the Two-Way Active Measurement Protocol (TWAMP) server and control clients.	*show services monitoring twamp server test-info*

Table 3: New CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description	Link
`show system applications (app` *app-name* `| brief | detail | node` *node-name*`)`	Display information about active applications on the system.	*show system applications (Junos OS Evolved)*
`show system errors`	Display information about faults in the system. **NOTE**: For Junos OS Evolved, only the QFX5200 supports this command. For all other Junos OS Evolved platforms, use the *show system errors active*, *show system errors count*, *show system errors error-id*, or *show system errors fru* command.	*show system errors*
`show system errors history`	Display information about faults in the system that have been cleared. **NOTE**: For Junos OS Evolved, only the QFX5200 supports this command. For all other Junos OS Evolved platforms, use the *show system errors active*, *show system errors count*, *show system errors error-id*, or *show system errors fru* command.	*show system errors history*
`show system nodes`	View a list of all nodes in the system.	*show system nodes*
`show system software add-restart`	Display all console messages from the last in-service software upgrade (ISSU).	*show system software add-restart (Junos OS Evolved)*
`show system software list`	Display the installed versions on all nodes in the system.	*show system software list*
`show system statistics backup`	Displays system statistics options for the backup Routing Engine. The options provided are the same as the options for `show system statistics`.	*show system statistics*

Table 3: New CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description	Link
`show system statistics jtd`	Displays system jtd statistics.	*show system statistics*
`show system ztp`	Junos OS Evolved implements ZTP using the Linux dhcp client. Users can find out the interfaces chosen by ZTP, arguments returned by DHCP, and ZTP state machine states.	*show system ztp*
`show trace`	Junos OS Evolved uses a new tracing infrastructure. This command shows the trace data from all nodes that are collected on the Routing Engine.	*show trace*
`show forwarding-options enhanced-hash-key`	Junos OS Evolved uses a new command to display the hashing algorithm to make hashing decisions. This command shows the data about which packet fields are used by the hashing algorithm.	*show forwarding-options enhanced-hash-key*
`show vlans`	Junos OS Evolved replaces the `show bridge` command with the `show vlans` command. This command displays detailed information on the VLAN configurations present on the Routing Engine and includes the following options: • `brief`: Display brief output. • `detail`: Display detailed output. • `extensive`: Display extensive output. • `instance`: Display information for a specified instance. • `interface`: Name of interface for which to display table. • `logical-system`: Name of logical system, or 'all'. • `operational`: Show operational bridging instance.	*show vlans*

Modified CLI Statements and Commands (Junos OS Evolved)

Some CLI statements and commands in Junos OS Evolved have a different set of options from Junos OS. For a list of these changes, see Table 4 on page 36.

NOTE: For the CLI commands that produce changed output, see Table 5 on page 47.

Table 4: Modified CLI Statements and Commands (Junos OS Evolved)

Statement or Command	Change in Junos OS Evolved	Link
Modified Statements		
[edit chassis error minor action]	The offline and disable-pfe actions are not available for errors with minor severity.	*error*
[edit firewall family *family-name* filter *filter-name*]	Egress filters do not support gre-key matches.	*promote*
[set forwarding options enhanced-hash-key]	The vxlan configuration options are not supported.	*show forwarding-options enhanced-hash-key*
[edit instance-type mac-vrf protocols evpn]	In Junos OS Evolved, instance-type mac-vrf protocols evpn is configured instead of instance-type evpn as in Junos OS.	*instance-type*
[edit instance-type virtual-switch protocols vpls]	In Junos OS Evolved, instance-type virtual-switch protocols vpls is configured instead of instance-type vpls as in Junos OS.	*instance-type*
[edit interfaces *interface-name* ether-options]	The following options are added to the ether-options statement: • fec • loopback-remote	*ether-options*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`[edit interfaces aggregated-interface-name aggregated-ether-options lacp]`	The following options for this command are not supported: • `accept-data` • `link-protection` • `no-peer-loopback-validation`	*Configuring Aggregated Ethernet LACP*
`[edit services monitoring twamp client control-connection test-session offload-type]`	In Junos OS Evolved, the option `inline-timestamping` is configured instead of the `hardware-timestamping` option as in Junos OS.	*test-session (Junos OS Evolved)*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`[edit system internet-options]`	In Junos OS Evolved, the following options are not supported: • `gre-path-mtu-discovery` • `icmpv4-rate-limit` • `icmpv6-rate-limit` • `ipip-path-mtu-discovery` • `ipv6-path-mtu-discovery-timeout` • `no-gre-path-mtu-discovery` • `no-ipip-path-mtu-discovery` • `no-ipv6-path-mtu-discovery` • `no-ipv6-reject-zero-hop-limit` • `no-source-quench` • `no-tcp-reset` • `no-tcp-rfc1323` • `no-tcp-rfc1323-paws` • `source-port` • `source-quench` • `tcp-drop-synfin-set`	*internet-options*
`host other-routing-engine`	In Junos OS Evolved, the `host other-routing-engine` statement is not available.	*Direct System Log Messages to a Remote Machine or the Other Routing Engine*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`[edit system commit]`	Junos OS Evolved does not support the following options: • `fast-synchronize` • `peers` • `peer-synchronize` • `commit-synchronize-server`	*commit (Commit Scripts)*
Modified Commands		
`clear ipv6 neighbors`	In Junos OS Evolved, issuing the `clear ipv6 neighbors` command clears the cache for IPv6 neighbors *that are in a reachable state*.	*clear ipv6 neighbors*
`monitor traffic interface`	The `write-file` option for the `monitor traffic interface`command takes precedence over the `extensive` option when you configure those two options simultaneously. If you try to configure these options at the same time, Junos OS Evolved gives you a warning message that the options are not compatible, and it only runs the `monitor traffic interface write-file` command.	*monitor traffic*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`ping`	Junos OS Evolved does not support the following `ping` command options: • `detail` • `logical-system` • `loose-source` • `mac-address` • `strict` • `strict-source` • `vpls`	*ping*
`request chassis routing-engine master switch`	The default wait time on the PTX10008 between Routing Engine switchovers when using the `request chassis routing-engine master switch` command has increased from 120 seconds to 360 seconds.	*request chassis routing-engine master*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`request system software add`	The following `request system software add` command options are not applicable in Junos OS Evolved: • `best-effort-load` • `both-routing-engines` • `chassis` • `device-alias` • `delay-restart` • `force-host` • `lcc` • `member` • `no-copy` • `on-primary` • `(re0 | re1)` • `re-choice` • `satellite` • `scc` • `set` • `sfc` • `upgrade-group` • `unlink` • `validate` • `validate-on-host`	*request system software add (Junos OS Evolved)*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
	• validate-on-routing-engine	
request system software delete	The following request system software delete command options are not applicable in Junos OS Evolved: • chassis • lcc • member • re-choice • scc • sfc • upgrade-group • unlink • validate • validate-on-host • validate-on-routing-engine	*request system software delete (Junos OS Evolved)*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`request system software rollback`	The following options are added to the `request system software rollback` command: • `(no-validate | validate)` • `with-old-snapshot-config` The following options are not applicable in Junos OS Evolved: • `device-alias` • `satellite` • `satellite-arg` • `upgrade-group`	*request system software rollback*
`request system software validate`	The following `request system software validate` command options are not applicable in Junos OS Evolved: • `chassis` • `lcc` • `member` • `package-options` • `scc` • `sfc`	*request system software validate (Junos OS Evolved)*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`request system storage cleanup`	Use the new option `force-deep` to clean up all user-generated files. The user is prompted to check the list of files to be deleted by using the `dry-run` option. The following options are not applicable in Junos OS Evolved: • re0 • re1 • routing-engine	*request system storage cleanup (Junos OS Evolved)*
`request security pki ca-certificate ca-profile-group load`	The `default` option is not supported on PTX10003-80C, PTX10003-160C, and PTX10008 routers.	*request security pki ca-certificate ca-profile-group load*
`request system zeroize`	The `local` option is removed. The command will reboot all Routing Engines on the local chassis when you issue the command.	*request system zeroize (Junos OS)*
`show agent sensors`	This command displays output on each Routing Engine, instead of just the primary Routing Engine.	*show agent sensors*
`show chassis fabric summary`	More detailed information is provided. The following fields are introduced: • `Link Error` • `Link TF` • `Reachability Errors (Local/Remote)` • `Uptime`	*show chassis fabric summary*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`show firewall`	The `application lsp` option allows you to specify the display of implicit policers that are published by rpd.	*show firewall*
`show host`	The `routing-instance mgmt_junos` option is introduced.	*show host*
`show system`	The `nodes` and `node-attributes` options are introduced.	*show system nodes*, *show system node-attributes*
`show system connections`	The `node` option is introduced. Junos OS Evolved does not support the following `show system connections` command options:. • `extensive` • `show-routing-instance`	*show system connections*
`show system core-dumps`	The `node` option is introduced. The core dump files generated on the nodes are stored in the **/var/core/** directory.	*show system core-dumps*
`show chassis errors`	The *error-id* option is moved to the `show system errors` tree.	*show system errors active*
`show chassis routing-engine errors`	The output for this command is moved to `show system errors`.	*show system errors active*
`show system memory`	The `node` option is introduced.	*show system memory*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`show system processes`	The following `show system processes` command options are not applicable in Junos OS Evolved: • `health` • `resource-limits`	*show system processes*
`show system storage`	The `node` option is introduced. The `invoke-on` option is removed.	*show system storage*
`show system virtual-memory`	The `node` option is introduced.	*show system virtual-memory*
`show version`	The `node` option is introduced.	*show version*
`ssh`	Junos OS Evolved does not support the following `ssh` command options: • `interface`	*ssh*
`telnet`	Junos OS Evolved does not support the following `telnet` command options: • `bypass-routing` • `interface` • `logical-system` • `no-resolve` • `source`	*telnet*

Table 4: Modified CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Change in Junos OS Evolved	Link
`traceroute`	Junos OS Evolved does not support the following `traceroute` command options: • `interface` • `logical-system` • `next-hop` • `port` • `propagate-ttl`	*traceroute*

Changed CLI Command Output (Junos OS Evolved)

For changes in output for Junos OS Evolved, see Table 5 on page 47.

Table 5: Changed Command Output (Junos OS Evolved)

Command	Description of Change in Output	Link
`clear interfaces statistics`	Clears not only LACP statistics but also the counters displayed in the `show lacp statistics interfaces` command.	*clear interfaces statistics*
`monitor traffic interface` *`interface-name`*	When you use the command `monitor traffic interface` *`interface-name`* on a logical interface, the output displays all packets received or transmitted on that interface, including Layer 2 traffic. When you use this command on a physical interface, the output only displays packets received and transmitted on the physical interface and does not include traffic from the logical interface.	*monitor traffic*
`ping`	When pinging a nonresponsive route, the display output of the `ping` command does not print the number of packets sent or received or the packet loss.	*ping*

Table 5: Changed Command Output (Junos OS Evolved) *(Continued)*

Command	Description of Change in Output	Link
`request system snapshot`	Output displays the names of the directory and the individual files being copied instead of only the directory names.	*request system snapshot (Junos OS Evolved)*
`request system software add`	For Junos OS Evolved, this command has a built-in feature to not start an upgrade if a reboot is pending after an upgrade or rollback.	*request system software add (Junos OS Evolved)*
`request system software delete`	Output displays the version instead of the package.	*request system software delete (Junos OS Evolved)*
`request system software rollback`	Output displays the version instead of the package.	*request system software rollback (Junos OS Evolved)*
The `show chassis environment cb` command does not show the Bus and FPGA revision information. Use the `show system firmware` command in order to view the FPGA revision or version information for the CB.	Use the `show chassis environment cb` command to display environmental information about the Control Boards (CBs).	*show chassis environment cb*
`show chassis environment fpc`	Displays different output.	*show chassis environment fpc*
`show interfaces ae`*`number`* `extensive`	LACP packets and LAG links on the members of an aggregated Ethernet interface are not counted as part of the bundle input or output statistics in the `show interfaces ae`*`number`* `extensive` command output.	*show interfaces (Aggregated Ethernet)*

Table 5: Changed Command Output (Junos OS Evolved) *(Continued)*

Command	Description of Change in Output	Link
`show interfaces`	Configuration of IPv6 over the re0:mgmt-* interfaces is supported.	*show interfaces*
`show interfaces detail`	Output displays the `Last Flapped` field with the value `Never` after a Routing Engine reboot. The `Last Flapped` field provides details of the date, time, and how long ago the interface went up. The value `Never` signifies that the interface never flapped.	*show interfaces detail*
`show interfaces extensive`	Output does not display the Packet Forwarding Engine configuration and CoS default bandwidth allocation information. Output displays zero for all loopback interface (lo0) statistics.	*show interfaces*
`show interfaces` *`interface-name`* `statistics`	Junos OS Evolved does not display statistics for an interface if it is a child of an aggregated ethernet (AE) interface.	*show interfaces statistics*
`show interfaces` *`interface-name`* `ifl-class`	Junos OS Evolved does not display statistics for an interface if it is a child of an aggregated ethernet (AE) interface.	*show interfaces statistics*
`show lldp local-information`	Output does not display "kernel JUNOS" in the system description field because Junos OS Evolved does not have a kernel.	*show lldp local-information*
`show multicast route extensive`	Output displays the `Sensor ID` field that corresponds to a multicast route.	*show multicast route*
`show multicast usage`	Output displays the `Sensor ID` field that corresponds to a multicast route.	*show multicast usage*
`show policer`	Output doesn't display the default ARP policer because it isn't needed in Junos OS Evolved. Distributed denial of service (DDoS) protection replaces the functionality of the default ARP policer.	*show policer*

Table 5: Changed Command Output (Junos OS Evolved) *(Continued)*

Command	Description of Change in Output	Link
`show snmp mib get`	Output for a Routing Engine displays the Routing Engine slot number, not the Routing Engine number.	*show snmp mib*
`show snmp mib walk`	The `show snmp mib walk jnxFilledDescr` output only shows the fan tray number. This output does not show the number of fan slots present in each tray.	*show snmp mib*
`show system errors fru detail`	Output displays status of FRUs including CB, chassis, fans, FPC, FPM, PDU, PICS, PSM, RE, and SIB, not just FPC.	*show system errors fru*
`show system memory`	Output displays the information per node, and the `System memory usage distribution` displays only the total, active, inactive, and free memory.	*show system memory*
`show system snapshot`	Output displays the snapshot device and a list of snapshots. The list shows the names of the snapshots instead of the version of the operating system. Output does not display the date the snapshot was created.	*show system snapshot (Junos OS Evolved)*
`show system statistics arp`	After running ping on an unreachable host, output shows that counts for `ARP requests received` and for `datagrams for an address not on the interface` are incremented.	*show system statistics arp*
`show system statistics tcp`	Output for the `show system statistics tcp` command is trimmed to show only fields supported in Junos OS Evolved.	*show system statistics tcp*
`show system uptime`	In certain releases, the output displays only the `System booted` and `System-wide users` information and does not display information on current time, system booted, protocols started, or last configured parameters. The `show system uptime node` command shows the other information.	*show system uptime*
`show task replication`	Output displays the same state whether the command is run from the primary or the backup Routing Engine.	*show task replication*

Table 5: Changed Command Output (Junos OS Evolved) *(Continued)*

Command	Description of Change in Output	Link
`show version`	Output of the `show version` command is changed to clearly show which Junos architecture is running on the device. Output of the `show version node all` command is revised to explicitly identify the Routing Engine in both the XML and CLI output.	*show version (Junos OS Evolved)*
`traceroute`	Output of the `traceroute` command displays MPLS data parsed in the same way as the Linux `traceroute` command: L=label, E=exp_use, S=stack_bottom, and T=TTL.	*traceroute*

Removed CLI Statements and Commands (Junos OS Evolved)

For a listing of which CLI statements and commands are removed from Junos OS Evolved, see Table 6 on page 51. Where there is an alternative statement or command to use, it is noted in the table.

Table 6: Removed CLI Statements and Commands (Junos OS Evolved)

Statement or Command	Description
Removed Statements	
`[edit forwarding-options analyzer]`	The `analyzer` application for port mirroring is not supported on Junos OS Evolved.

`[edit forwarding-options enhanced-hash-key ecmp-dlb ether-type]`
 	
`[edit forwarding-options enhanced-hash-key lag-dlb ether-type]`
	On QFX5130 and QFX5700 devices, `ether-type` is not supported on Junos OS Evolved.

`[edit system services extension-service notification]`	Junos OS Evolved does not support the notification service for JET applications.

Table 6: Removed CLI Statements and Commands (Junos OS Evolved) *(Continued)*

Statement or Command	Description
[set chassis fabric degraded action-on-non-blackhole-degradation *percentage*] [set chassis fabric degraded action-on-per-plane-fpc-degradation *percentage*]	These commands are replaced by [set chassis fabric event reachability-fault degraded error-threshold *percentage*].
Removed Commands	
gigether-options	The gigether-options statement at the [edit interfaces *interface-name*] hierarchy no longer appears because it is not needed. To configure link aggregation groups (LAG), use the set interfaces *interface-name*ether-options command instead.
request chassis beacon service-node	This command is removed from Junos OS Evolved.
request system core-dump	This command is removed from Junos OS Evolved.
request system recover	This command is removed from Junos OS Evolved.
request system scripts (delete | rollback)	AI-Scripts and Service Now are not supported on Junos OS Evolved.
request system software abort	This command is removed because the request system software add command has a built-in feature not to start an upgrade if a reboot is pending after an upgrade or rollback.
request system software (add | delete) set	Junos OS Evolved bundles all packages into one single ISO file, so the set option serves no purpose in the request system software add and request system software delete commands.

Table 6: Removed CLI Statements and Commands (Junos OS Evolved) ***(Continued)***

Statement or Command	Description
`request system software in-service-upgrade`	Use the `request system software add restart` command for ISSU. The `request system software add` command has a built-in feature not to start upgrade if a reboot is pending after an upgrade or rollback.
`request system software set`	To set the current system to an installed software version, use the `request system software rollback reboot` command.
`request system storage user-disk`	There are no satellite packages in Junos OS Evolved.
`show bridge`	The command `show bridge` is replaced by the command `show vlan` in Junos OS Evolved.
`show chassis fabric unreachability`	See the `show system errors` command for similar functionality.
`show chassis memory-usage-chassisd`	The functionality for this command and all options under this command are moved to `show system memory`.
`show chassis network-services`	This command is not supported.
`show chassis routing-engine errors`	This command has been replaced by `show system errors` in Junos OS Evolved.
`show class-of-service forwarding-table`	The removed options include `classifier`, `classifier mapping`, `drop-profile`, `policer`, `rewrite-rule`, `rewrite-rule mapping`, `scheduler-map`, and `shaper`.
`show database-replication`	This command is not supported.
`show firewall family inet filter` **filter-name** `term` **term-name** `then traffic-class-count`	The `traffic-class-count` option is not supported under the firewall hierarchy in Junos OS Evolved.

Table 6: Removed CLI Statements and Commands (Junos OS Evolved) ***(Continued)***

Statement or Command	Description
`show interfaces mac-database`	This command is not supported.
`show interfaces mc-ae`	This command has been replaced with `show multi-chassis mc-lag`.
`show system buffers`	This command is removed starting in Junos OS Evolved Releases 21.1R1 and 20.3R2. This command is not applicable in Junos OS Evolved because the command displays the status of kernel mbufs, which are not used in Linux-based systems like Junos OS Evolved.
`show system software detail`	Use `show system software list` to display a list of the software versions installed on all nodes. For more details about the software, use `show version detail`.
`show system uptime invoke-on`	This command is removed from Junos OS Evolved.
`traceoptions`	Junos OS Evolved removes the `traceoptions` option at many hierarchy levels because trace messages are now logged, viewed, and configured per application. However, some routing protocols (the `[edit protocols]` hierarchy level) and a few other applications still use `traceoptions`.

XML Differences Between Junos OS and Junos OS Evolved

This section lists the differences in XML output between Junos OS and Junos OS Evolved.

request system storage cleanup

In Junos OS, the XML output of `request system storage cleanup` uses the `<file-list>` XML tag for all file types in the list of files to be deleted. In Junos OS Evolved, the XML output groups different file types inside different XML tags, for example, `<core-file-list>` and `<log-file-list>`. Additionally, the command targets all nodes on Junos OS Evolved, so a `<node>` element encloses the output for each node.

request system storage cleanup (Junos OS)

```
user@host> request system storage cleanup | display xml
<rpc-reply xmlns:junos="http://xml.juniper.net/junos/18.4I0/junos">
    <system-storage-cleanup-information>
        <file-list junos:style="normal">
            <file>
                <file-name>/var/log/dfcd_enc.0.gz</file-name>
                <size junos:format="551B">551</size>
                <date>Nov 23 15:33</date>
            <file>
        </file-list>
    </system-storage-cleanup-information>
</rpc-reply>
```

request system storage cleanup (Junos OS Evolved)

```
user@host> request system storage cleanup | display xml
<rpc-reply xmlns:junos="http://xml.juniper.net/junos/19.1I0/junos">
    <system-storage-cleanup-information>
        <node>
            <node-name> RE0 </node-name>
            <core-file-list>
                <description>List of all core files to be cleared: </description>
                <file>
                    <file-name>/var/core/re0/auditd.re.re0.17130.2019_02_28.03_39_36.tar.gz</
file-name>
                    <size>3.8M</size>
                    <date>Thu Feb 28 03:40</date>
                </file>
            </core-file-list>
            <core-local-host-file-list>
            </core-local-host-file-list>
            <core-subdir-file-list>
            </core-subdir-file-list>
            <fpc-file-list>
            </fpc-file-list>
            <logical-systems-file-list>
            </logical-systems-file-list>
            <log-file-list>
                <description>Clears all App logs, App traces and App SI traces
```

```
under /var/log/*, /var/log/traces/* and /var/log/si_traces/* </description>
            </log-file-list>
            <iso-file-list>
            </iso-file-list>
        </node
    </system-storage-cleanup-information>
</rpc-reply>
```

show system memory

In Junos OS Evolved, the `show system memory` XML output is changed to better reflect the way Linux manages memory. The output comprises a top-level `<multi-routing-engine-results>` element and one `<multi-routing-engine-item>` child element for each node, which contains the node name and the `<system-memory-information>` for that node. In Junos OS, the device only emits a `<system-memory-information>` element. Additionally, the `<system-memory-summary-information>` includes the following new child elements:

- `<system-memory-used>` and `<system-memory-used-percent>`
- `<system-memory-buffer>` and `<system-memory-buffer-percent>`
- `<system-memory-swap>` and `<system-memory-swap-percent>`

and omits the following elements:

- `<system-memory-reserved>` and `<system-memory-reserved-percent>`
- `<system-memory-wired>` and `<system-memory-wired-percent>`
- `<system-memory-cache>` and `<system-memory-cache-percent>`

```
user@host> show system memory | display xml
<rpc-reply xmlns:junos="http://xml.juniper.net/junos/22.1R0/junos">
    <multi-routing-engine-results>
        <multi-routing-engine-item>
            <re-name>fpc1</re-name>
            <system-memory-information>
                <system-memory-summary-information>
                    <system-memory-total>16125892</system-memory-total>
                    <system-memory-total-percent>100%</system-memory-total-percent>
                    <system-memory-used>3885112</system-memory-used>
                    <system-memory-used-percent>24%</system-memory-used-percent>
                    <system-memory-active>2447796</system-memory-active>
                    <system-memory-active-percent>15%</system-memory-active-percent>
```

```
                    <system-memory-inactive>2101128</system-memory-inactive>
                    <system-memory-inactive-percent>13%</system-memory-inactive-percent>
                    <system-memory-free>9327316</system-memory-free>
                    <system-memory-free-percent>57%</system-memory-free-percent>
                    <system-memory-buffer>314516</system-memory-buffer>
                    <system-memory-buffer-percent>1%</system-memory-buffer-percent>
                    <system-memory-swap>2598948</system-memory-swap>
                    <system-memory-swap-percent>16%</system-memory-swap-percent>
                </system-memory-summary-information>
                <pmap-terse-information xmlns="http://xml.juniper.net/fbsd10/14.2I0/junos-pmap">
                    <pmap-terse-summary junos:style="pmap-process-terse-summary">
                        <pid>1</pid>
                        <process-name>/lib/systemd/systemd</process-name>
                        <size>159116</size>
                        <size-percent>0</size-percent>
                        <resident>8408</resident>
                        <resident-percent>0</resident-percent>
                    </pmap-terse-summary>
                    ...
                </pmap-terse-information>
            </system-memory-information>
        </multi-routing-engine-item>
        <multi-routing-engine-item>
            <re-name>re0</re-name>
            <system-memory-information>
                <system-memory-summary-information>
                    <system-memory-total>16125576</system-memory-total>
                    <system-memory-total-percent>100%</system-memory-total-percent>
                    <system-memory-used>6912492</system-memory-used>
                    <system-memory-used-percent>42%</system-memory-used-percent>
                    <system-memory-active>4936580</system-memory-active>
                    <system-memory-active-percent>30%</system-memory-active-percent>
                    <system-memory-inactive>8939976</system-memory-inactive>
                    <system-memory-inactive-percent>55%</system-memory-inactive-percent>
                    <system-memory-free>170744</system-memory-free>
                    <system-memory-free-percent>1%</system-memory-free-percent>
                    <system-memory-buffer>524676</system-memory-buffer>
                    <system-memory-buffer-percent>3%</system-memory-buffer-percent>
                    <system-memory-swap>8517664</system-memory-swap>
                    <system-memory-swap-percent>52%</system-memory-swap-percent>
                </system-memory-summary-information>
                <pmap-terse-information xmlns="http://xml.juniper.net/fbsd10/14.2I0/junos-pmap">
                    <pmap-terse-summary junos:style="pmap-process-terse-summary">
```

```
                        <pid>1</pid>
                        <process-name>/sbin/init</process-name>
                        <size>162220</size>
                        <size-percent>0</size-percent>
                        <resident>10780</resident>
                        <resident-percent>0</resident-percent>
                    </pmap-terse-summary>
                    ...
                </pmap-terse-information>
            </system-memory-information>
        </multi-routing-engine-item>
        ...
    </multi-routing-engine-results>
```

show system processes

On certain platforms running Junos OS Evolved Release 20.3R1 or earlier, the XML output for the `show system processes` command and the `show system processes wide` command is the CLI output enclosed in an `<output>` element. Starting in Junos OS Evolved Release 20.4R1, the XML output matches the Junos OS XML output.

show system processes (Junos OS)

```
user@host> show system processes | display xml | no-more
<rpc-reply xmlns:junos="http://xml.juniper.net/junos/20.1R0/junos">
    <system-process-information junos:style="brief">
        <process-information>
              <process>
                <pid>0</pid>
                <terminal-name>- </terminal-name>
                <state>DLs</state>
                <cpu-time>8:39.74</cpu-time>
                <command>[kernel]</command>
              </process>
              <process>
                <pid>1</pid>
                <terminal-name>- </terminal-name>
                <state>ILs</state>
                <cpu-time>0:00.25</cpu-time>
                <command>/sbin/init --</command>
              </process>
              ...
```

```
        </process-information>
    </system-process-information>
    <cli>
        </banner>
    </cli>
</rpc-reply>
```

show system processes (Junos OS Evolved)

```
user@host> show system processes | display xml | no-more
<rpc-reply xmlns:junos="http://xml.juniper.net/junos/20.2I0/junos">
    <output>
        ------------------------------
        node: re0
        ------------------------------
        UID        PID  PPID  C    SZ   RSS PSR STIME TTY          TIME CMD
        root         1     0  0  9947  2732   1 Apr10 ?        00:00:22 /sbin/init --dump-core
        root         2     0  0     0     0   5 Apr10 ?        00:00:00 [kthreadd]
        root         3     2  0     0     0   0 Apr10 ?        00:00:20 [ksoftirqd/0]
        root         5     2  0     0     0   0 Apr10 ?        00:00:00 [kworker/0:0H]
        root         7     2  0     0     0   5 Apr10 ?        00:04:20 [rcu_preempt]
        ...
    </output>
    <cli>
        </banner>
    </cli>
</rpc-reply>
```

show system processes wide (Junos OS)

```
user@host> show system processes wide | display xml | no-more
<rpc-reply xmlns:junos="http://xml.juniper.net/junos/20.1R0/junos">
    <system-process-information junos:style="brief">
        <process-information>
              <process>
                <pid>0</pid>
                <terminal-name>- </terminal-name>
                <state>DLs</state>
                <cpu-time>8:39.86</cpu-time>
                <command>[kernel]</command>
              </process>
```

```
            <process>
              <pid>1</pid>
              <terminal-name>- </terminal-name>
              <state>ILs</state>
              <cpu-time>0:00.25</cpu-time>
              <command>/sbin/init --</command>
            </process>
            ...
        </process-information>
    </system-process-information>
    <cli>
        </banner>
    </cli>
</rpc-reply>
```

show system processes wide (Junos OS Evolved)

```
user@host> show system processes wide | display xml | no-more
<rpc-reply xmlns:junos="http://xml.juniper.net/junos/20.2I0/junos">
    <output>
        ------------------------------
        node: re0
        ------------------------------
        UID        PID  PPID  C    SZ   RSS PSR STIME TTY          TIME CMD
        root         1     0  0  9947  2732   0 Apr10 ?        00:00:22 /sbin/init --dump-core
        root         2     0  0     0     0   5 Apr10 ?        00:00:00 [kthreadd]
        root         3     2  0     0     0   0 Apr10 ?        00:00:20 [ksoftirqd/0]
        root         5     2  0     0     0   0 Apr10 ?        00:00:00 [kworker/0:0H]
        root         7     2  0     0     0   0 Apr10 ?        00:04:20 [rcu_preempt]
        ...
    </output>
    <cli>
        </banner>
    </cli>
</rpc-reply>
```

Default Directories for Junos OS Evolved File Storage

Junos OS Evolved files are stored in the following directories on the device:

- **/boot**—This directory contains the boot loader and associated files.
- **/config**—This directory contains the current operational router or switch configuration and the last three committed configurations, in the files **juniper.conf**, **juniper.conf.1**, **juniper.conf.2**, and **juniper.conf.3**, respectively. The **/config/scripts** directory contains all stored scripts.
- **/data**—This is the directory for all mutable copies of mutable directories. It contains the following subdirectories:
  - **/config**—Contains version-specific Juniper configuration files. This directory is bind mounted to **/config**, meaning that changes in either directory will be reflected in both directories.
  - **/etc**—Contains version-specific Linux configuration files. This directory is bind mounted to **/etc**.
    - **/var/etc**—Contains SSH host keys.
  - **/var**—Shared writable directory for all software versions. This directory is bind mounted to **/var**.
  - **/var_db**—Contains version-specific **/var/db** files. This directory is bind mounted to **/var/db**.
  - **/var_db_scripts**—Contains subdirectories for various script types. Scripts are stored in and executed from these directories. This directory is bind mounted to **/var/db/scripts**.
    - **/var/db/scripts/commit**—Contains commit scripts.
    - **/var/db/scripts/op**—Contains op scripts.
    - **/var/db/scripts/event**—Contains event scripts.
    - **/var/db/scripts/snmp**—Contains SNMP scripts.
    - **/var/db/scripts/lib**—Contains imported scripts.
  - **/var_etc**—Contains version-specific **/var/etc** files. This directory is bind mounted to **/var/etc**.
  - **/var_pfe**—Contains version-specific PFE configuration files. This directory is bind mounted to **/var/pfe**.
  - **/var_rundb**—Contains UI-related runtime-generated database files that are shared across versions. This directory is bind mounted to **/var/rundb**.
- **/soft**—This directory is the software install area. All software versions are installed here.

- **/u**—This directory is a read-only file system for the running version of Junos OS Evolved.
- **/var**—This directory contains the following subdirectories:
  - **/home**—Contains users' home directories, which are created when you create user access accounts. For users using SSH authentication, their **.ssh** file, which contains their SSH key, is placed in their home directory. When a user saves or loads a configuration file, that file is loaded from the current working directory unless the user specifies a full pathname.
  - **/db/config**—Contains up to 46 previous versions of committed configurations, which are stored in the files **juniper.conf.4.gz** through **juniper.conf.49.gz**.
  - **/log**—Contains system log and tracing files.
  - **/core**—Contains core files. The software saves up to five core files, numbered from 0 through 4. File number 0 is the oldest core file and file number 4 is the newest core file. To preserve the oldest core files, the software overwrites the newest core file, number 4, with any subsequent core file.
  - **/tmp**—Contains temporary files, including files that are generated when a crash event is detected.

RELATED DOCUMENTATION

Junos OS Evolved Overview | 2

Junos OS Evolved Components and Processes

IN THIS SECTION

A Junos OS Evolved system is comprised of one or more Linux nodes, coupled together with an efficient communications substrate, and supplied with a distributed application launcher. A horizontal software layer decouples application processes from the specific hardware node where they can be run. Applications use the Distributed Data Store (DDS) to share state, and state is synchronized between nodes. A high-level description of the various software components is listed below.

Linux Kernel

Junos OS Evolved is built on top of a stock Linux kernel. Functionality performed by the router like configuration management, interface management and routing are processes that run as Linux processes. All applications run natively on the Linux kernel, including Juniper and non-Juniper applications.

Initialization Process

When the device boots, an initialization process (init) starts and monitors all the other software processes.

If a software process terminates or fails to start when called, the init process attempts to restart it a limited number of times and logs any failure information for further investigation.

System Epoch Management Process

The system epoch management process (SysEpochMan) is responsible for organizing the various Linux nodes into a cohesive system, and to monitor the system to ensure integrity if any nodes fail. If the system needs to be restarted, SysEpochMan ensures a clean transition from the previous system state to the new system state.

System Manager Process

The system manager process (SysMan) is responsible for the launching, coordination, and monitoring of applications in Junos OS Evolved. The SysMan Master oversees the placement of applications on nodes as specified by each application, and communicates its decisions to the local SysMan instances. If an application fails, the local SysMan process will detect the failure, and take corrective action based on what is specific for the application.

Management Process

The management process (mgd) manages the configuration of the router and all user commands. The management process is responsible for managing all user access to the device and for notifying other processes when a new configuration is committed. A dedicated management process handles Junos XML protocol XML requests from its client, which might be the CLI or any Junos XML protocol client.

Routing Protocol Process

Within Junos OS Evolved, the routing protocol process (rpd) controls the routing protocols that run on the device. The rpd process starts all configured routing protocols and handles all routing messages. It maintains one or more routing tables, which consolidate the routing information learned from all routing protocols. From this routing information, the routing protocol process determines the active routes to network destinations and installs these routes into the Routing Engine's forwarding table. Finally, rpd implements routing policy, which enables you to control the routing information that is transferred between the routing protocols and the routing table. Using routing policy, you can filter and limit the transfer of information as well as set properties associated with specific routes.

Interface Process

The Junos OS Evolved interface process (Ifmand) is responsible managing all interfaces on the device. Ifmand creates all the operational state related to interfaces (IFD, IFL, IFF, IFA) as well as the necessary interface specific routes and nexthops.

Ifmand enables you to configure and control the physical interface devices and logical interfaces present in a network device. You can configure interface properties such as the interface location, for example, in which slot the Flexible PIC Concentrator (FPC) is installed and in which location on the FPC the Physical Interface Card (PIC) is installed, as well as the interface encapsulation and interface-specific

properties. You can configure the interfaces currently present in the device, as well as interfaces that are not present but that you might add later.

Distributor Process

The distributor process is responsible for holding the Distributed Data Store (DDS) and coordinating with individual applications for delivery of their state. The distributor process synchronizes state across the system.

SNMP and MIB II Processes

Junos OS Evolved supports the Simple Network Management Protocol (SNMP), which helps administrators monitor the state of a device. The software supports SNMP version 1 (SNMPv1), version 2 (SNMPv2, also known as version 2c, or v2c), and version 3 (SNMPv3).

ZooKeeper Process

The ZooKeeper process is a synchronous transport service that helps in the election of active services, locks resources to avoid data inconsistency, and allocates resources like IP addresses.

Process Limits

There are limits to the total number of Junos OS Evolved processes that can run simultaneously on a device. There are also limits set for the maximum number of iterations of any single process. The limit for iterations of any single process can only be reached if the limit of overall system processes is not exceeded.

Error TPAs for Route Installation

SUMMARY

If you configure this feature, during route installations the consumer of a state update notifies the producing application when there are errors in processing the state update sent by the producer. The producer then attaches a third-party attachment (TPA) object on top of the errored object, with details of the error, and publishes it.

IN THIS SECTION

Overview of Error Third-Party Attachments (TPAs) on Errored Objects During Route Installations

In a distributed system, states can be produced anywhere and consumed anywhere, making it difficult for a producer (for example, a PFE) to determine whether the system is in the correct state for the consumer (for example, an rpdagent). If you configure this feature, during route installations the consumer notifies the producing application when there are errors in processing the state update sent by the producer. The producer then attaches a TPA object on top of the errored object with details of the error and publishes it.

Details of errors include:

- errorID
- severity
- obj_guid
- error_description
- error_module
- error_object_name
- error_timestamp
- error_producer_name
- natural_name

The errors generated have standard error numbers.

The forwarding information base (FIB) telemetry daemon (FIBtd) also receives error notifications. You use the Junos telemetry interface (JTI) and remote procedure calls (gRPC) services to stream or export ON_CHANGE FIB statistics to an outside SDN collector. Set the collector to subscribe to xpath **/state/system/anomalies/fib/** to get both the IPv4 and IPv6 error routes.

You can use the CLI to query errored objects and related information. To avoid flooding the system with error objects, the number of published error objects from a producer is set to a threshold limit of 20,000. Once the threshold is reached, no more error objects are published. However, errored objects and related information is still saved, you can query it using CLI

The consumer is notified when the errors are cleared and the route installation is successful.

Set Up the System for Error TPAs

SUMMARY

1. Configure FIP streaming on the client device.

```
set system fib-streaming
set system services extension-service request-response grpc max-connections number
set system services extension-service request-response grpc skip-authentication
set system services extension-service notification allow-clients address ip-address
set system services extension-service request-response grpc clear-text port port-number
```

2. On the collector, subscribe to the xpath **/state/system/anomalies/fib/** to get both the IPv4 and IPv6 error routes.

CLI Commands for Viewing Error Details

SUMMARY

Use the following CLI commands to view details of error TPAs that are generated during route installations:

Table 7: CLI Commands to View Error TPA Information

Command	Example	Link
show system applications	show system applications error app rpdagent node re0	*show system applications (Junos OS Evolved)*
show fib-streaming	show fib-streaming native-model route-errors inet	*show fib-streaming*
show agent sensors	–	*show agent sensors*

Shell Commands for Junos OS Evolved

IN THIS SECTION

Shell commands are Linux commands that are executed through the Linux shell rather than the Junos OS Evolved CLI. Junos OS Evolved supports existing Linux shell commands. This topic lists commonly used shell commands for Junos OS Evolved.

How to Use the Shell

To start the Linux shell, enter the `start shell` command from the Junos OS Evolved CLI. When you are in the shell, the command prompt will change to the following format:

```
username@hostname:~$
```

Once the shell is active, you can enter shell commands using the shell prompt. To return to the Junos OS Evolved CLI, use the `exit` command.

Common Shell Commands

The following table lists some of the shell commands that are useful for operating a Junos OS Evolved device:

Table 8: Junos OS Evolved Shell Commands

Command	Description
sync	Synchronize the Routing Engines This command should only be used in situations where the CLI cannot be accessed.
reboot	Reboot the current Routing Engine. This command should only be used in situations where the CLI cannot be accessed.
/sbin/upgrade /var/tmp/*iso*	Upgrade the current Routing Engine using the specified .iso file. This command should only be used in situations where the CLI cannot be accessed.
vssh *node-name*	Open a SSH session to the remote node from the Routing and Control Board.
chvrf iri *network-command*	Creates the network context required to access the control plane and reach other nodes.

Table 8: Junos OS Evolved Shell Commands *(Continued)*

Command	Description
systemctl enable --now docker.service	Enable automatic startup for the Docker container service
who	Displays a list of users logged into the device. Hostname is displayed for users connected via telent and IP address is displayed for users connected via SSH.
ecmp-tracer --*interface* &	Displays the forwarding packets going through an interface.

RELATED DOCUMENTATION

Junos OS Evolved Overview | 2

Where to Find Information on Common Procedures

This guide, *Introducing Junos OS Evolved,* has information about the features and changes in the next generation of Junos OS. However, much about using Junos OS remains the same. Junos OS Evolved has the same CLI user interface, some of the same processes, and the same management and automation tools as Junos OS. You configure and manage Junos OS Evolved the same way as you always have configured and managed Junos OS.

For your convenience, this section lists some links to the Junos OS documentation you might want to consult.

- Getting Started with Junos OS Evolved—Procedures for initial configuration.
- User Access and Authentication Administration Guide for Junos OS Evolved—Procedures on granting access and setting up authentication on your device.
- Network Management and Monitoring Guide—Procedures on SNMP, remote monitoring (RMON), destination class usage (DCU) and source class usage (SCU) data, accounting profiles, and logging.
- Junos® OS Evolved Software Installation and Upgrade Guide—Procedures for installing and upgrading Junos OS Evolved software.
- CLI User Guide for Junos OS Evolved—Procedures on using the CLI for Junos OS Evolved software.

2

CHAPTER

Junos OS Evolved Configuration Overview

IN THIS CHAPTER

Junos OS Evolved Configuration Basics

Your compatible Juniper Networks device comes with Junos OS Evolved installed on it, unless you specifically order it without the operating system. When Junos OS Evolved is pre-installed, you simply power on the device and all software starts automatically. You just need to configure the device so it will be ready to participate in the network.

To configure the Junos OS Evolved, you must specify a hierarchy of configuration statements which define the preferred software properties. You can configure all properties of the Junos OS Evolved, including interfaces, general routing information, routing protocols, and user access, as well as some system hardware properties. After you have created a candidate configuration, you commit the configuration to be evaluated and activated by Junos OS Evolved.

RELATED DOCUMENTATION

- Junos OS Evolved Configuration from External Devices | 75
- Methods for Configuring Junos OS Evolved | 72
- Junos OS Evolved Overview | 2

Methods for Configuring Junos OS Evolved

IN THIS SECTION

Depending on specific device support, you can use the methods shown here to configure Junos OS Evolved. For more information, see the Juniper Networks Feature Explorer.

Table 9: Methods for Configuring Junos OS Evolved

Method	Description
Command-line interface (CLI)	Create the configuration for the device using the CLI. You can enter commands from a single command line, and scroll through recently executed commands.
ASCII file	Load an ASCII file containing a configuration that you created earlier, either on this system or on another system. You can then activate and run the configuration file, or you can edit it using the CLI and then activate it.
Junos XML management protocol (API)	Client applications use the Junos XML management protocol to monitor and configure Juniper Networks devices. The Junos XML management protocol is customized for Junos OS Evolved, and operations in the API are equivalent to those in the Junos OS Evolved CLI.
NETCONF application programming interface (API)	Client applications use the NETCONF XML management protocol to monitor and configure supported devices. The NETCONF XML management protocol includes features that accommodate the configuration data models of multiple vendors.
Configuration commit scripts	Create scripts that run at commit time to enforce custom configuration rules. Commit scripts are written in Python, Stylesheet Language Alternative syntaX (SLAX), or Extensible Stylesheet Language Transformations (XSLT).

The following sections describe the methods you can use to configure Junos OS Evolved:

Junos OS Evolved Command-Line Interface

The Junos OS Evolved CLI is a straightforward terminal-based command interface. You use Emacs-style keyboard sequences to move around on a command line and scroll through a buffer that contains recently executed commands. You type commands on a single line, and the commands are executed when you press the Enter key. The CLI also provides command help and command completion.

ASCII File

You can load an ASCII file containing a configuration that you created earlier, either on this system or another system. You can then activate and run the configuration file as is, or you can edit it using the CLI and then activate it.

Junos XML Management Protocol Software

The Junos XML Management Protocol is an XML-based protocol that client applications use to monitor and configure Juniper Networks devices. It uses an XML-based data encoding for the configuration data and remote procedure calls. This API is customized for Junos OS Evolved, and operations in the API are equivalent to CLI commands.

NETCONF XML Management Protocol Software

The NETCONF XML management protocol is an XML-based protocol that client applications use to monitor and configure network devices. It uses an XML-based data encoding for the configuration data and remote procedure calls. NETCONF includes features that accommodate the configuration data models of multiple vendors. Juniper Networks provides a set of Perl modules that enable Perl client applications to communicate with the NETCONF server on Junos devices. The Perl modules enable you to develop custom applications for configuring and monitoring Junos OS Evolved.

Configuration Commit Scripts

You can create and use scripts that run at commit time to enforce custom configuration rules. If a configuration breaks the custom rules, the script can generate actions that the Junos OS Evolved performs. These actions include:

- Generating custom error messages
- Generating custom warning messages
- Generating custom system log messages
- Making changes to the configuration

Configuration commit scripts also enable you to create macros, which expand simplified custom aliases for frequently used configuration statements into standard Junos OS Evolved configuration statements. Commit scripts are written in Python, Stylesheet Language Alternative syntaX (SLAX), or Extensible Stylesheet Language Transformations (XSLT).

RELATED DOCUMENTATION

- CLI Explorer
- CLI User Guide
- Junos OS Evolved Configuration from External Devices | 75
- NETCONF XML Management Protocol Developer Guide
- Junos OS Evolved Overview | 2

Junos OS Evolved Configuration from External Devices

You can configure a Junos OS Evolved network device from a *system console* connected to the console port or by using *Telnet* to access the device remotely. External management hardware can be connected to the Routing Engine and the Junos OS Evolved through these ports:

- Console port
- Auxiliary port
- Ethernet management port

NOTE: See hardware guide for your particular Junos OS Evolved device for instructions about how to connect external hardware to the console, auxiliary, and/or Ethernet management ports. Capabilities and features can vary depending on device model.

RELATED DOCUMENTATION

- Methods for Configuring Junos OS Evolved | 72
- Junos OS Evolved Overview | 2

3

CHAPTER

Running 3rd Party Applications with Junos OS Evolved

IN THIS CHAPTER

Overview of Third-Party Applications on Junos OS Evolved

SUMMARY

You can run third-party applications inside Linux containers or natively on Junos OS Evolved with signing keys. Applications use Juniper APIs to interact with the Junos OS Evolved system, and Linux APIs for network tasks. Unverified applications are prevented by an integrity solution called Integrity Measurement Architecture (IMA).

IN THIS SECTION

Introduction to Third-Party Applications on Junos OS Evolved

Junos OS Evolved runs natively on Linux, which means you can integrate third-party applications and tools developed for Linux into Junos OS Evolved. Linux development tools also give you the power to create and run your own applications on Junos OS Evolved. You can choose to run these applications inside a container, or natively on the device with signing keys.

Running Applications in Containers

Junos OS Evolved supports running applications inside Docker containers. Containers run on Junos OS Evolved, and applications run inside the containers, keeping them isolated from the OS. You can use prebuilt Docker container images and install additional tools and libraries inside the container. Containers can be upgraded by using Linux workflow.

Containers are already a commonly used method for running Linux applications, so many existing third-party applications can be easily imported into Junos OS Evolved by deploying them inside containers. The isolated nature of containers makes them easy to deploy and remove without compromising the

integrity of Junos OS Evolved. In addition, Junos OS Evolved places default limits on the resource usage of containers, to ensure that rogue containers cannot overwhelm your system.

The Docker container service is not automatically started at system initialization. To enable automatic startup for the Docker container service, enter the following command from the Linux shell:

- `# systemctl enable --now docker.service`

For more information about running applications in containers, see "Running Third-Party Applications in Containers" on page 81

Running Applications Natively With Signing Keys

Third-party applications can run natively on Junos OS Evolved by using signing keys. You generate signing keys and use them to sign executable files or shared objects. Signing an executable file gives it permission to run on the device, allowing you to approve trusted applications to run alongside authorized Juniper Networks software.

Signing keys are controlled by a Linux subsystem called Integrity Measurement Architecture (IMA). IMA policy consists of rules that define which actions needs to be taken before a file can be executed. IMA measurement policy will measure and store a file's hash, and IMA appraisal policy will make sure that the file has a valid hash or digital signature. IMA will only allow a file to run if this validation succeeds.

Junos OS Evolved requires users to sign all files that will be mapped into memory for execution. IMA verification helps ensure that these files have not been accidentally or maliciously altered. Containers and files inside containers do not need to be signed.

For more information about using signing keys, see "Signing Third-Party Applications to Run Natively on Junos OS Evolved" on page 89

Application Pre-requisites

Third party applications are supported for the following Junos OS Evolved releases:

- Junos OS Evolved release 20.1R1 and later for applications in containers.
- Junos OS Evolved release 22.4R1 and later for native applications.
- Junos OS Evolved release 23.2R1 and later for dual Routing Engine applications.

Applications must support the Linux kernel version running on Junos OS Evolved to work properly. Use the `show version` command to view the currently running Linux kernel version.

Applications written for Junos OS Evolved typically require the ability to read and modify the networking state, to send and receive packets, and to read and modify the configuration. Junos OS Evolved supports a limited number of APIs, so applications must be configured with these APIs in mind.

Application APIs

There are two categories of APIs used by applications:

- Linux APIs for reading and modifying the networking state, and sending and receiving packets.
- Juniper APIs for interacting with the system.

Junos OS Evolved supports these two categories of APIs. Table 10 on page 79 provides a high-level view of the set of APIs used by applications:

Table 10: Application APIs

API	*Functionality*
Packet IO and Linux socket APIs	Ability to send and receive packets over mgmt and/or data interfaces. Standard libc – send, receive, listen, etc.
rtnetlink	Ability to use rtnetlink to query networking state like interfaces, routes, etc.
netdevice	Ability to configure network devices.
proc	Ability to query kernel data structures using standard interfaces provided by Linux kernel.
Junos APIs	Ability to access Juniper Northbound APIs - NetConf/JET/Telemetry.

NOTE: For more information on Juniper Northbound APIs, see the following:

- Overview of JET APIs
- NETCONF XML Management Protocol and Junos XML API Overview

- Overview of the Junos Telemetry Interface

Security Caveats

Junos OS Evolved is designed from the ground up with security in mind. IMA and Linux containers help to control the security impact of third-party applications on Junos OS Evolved, but third-party applications still have the potential to introduce security vulnerabilities through malicious code.

Always consider the security implications of adding a third-party application to Junos OS Evolved. Make sure any applications you add to Junos OS Evolved are thoroughly vetted for potential security risks.

File Security with IMA

Network devices that run Junos OS Evolved are protected by an integrity solution called Integrity Measurement Architecture (IMA).

Integrity is a fundamental security property that represents trust, completeness, and freedom from alteration. In computer security, common targets for integrity protections are operating system files. A common method of ensuring integrity is to compare a file against a known good file.

In the context of Junos OS Evolved, the security goal is to ensure that the software running on a device has not been accidentally or maliciously altered. The software running on a device is either authentic Junos software from Juniper Networks or authorized software deployed by a customer.

The threat model for network devices includes attempts by malicious actors to deploy malware that violates either the implicit or explicit policies of device owners. Such malware could include back doors, Trojan horses, or implants that could adversely the safe and secure operation of devices or networks. Malicious actors use a variety of tools, techniques, and procedures to breach integrity including physical attacks, local attacks, and remote attacks.

Many regulatory schemes levy file integrity requirements, including PCI-DSS - Payment Card Industry Data Security Standard (Requirement 11.5), SOX - Sarbanes-Oxley Act (Section 404), NERC CIP - NERC CIP Standard (CIP-010-2), FISMA - Federal Information Security Management Act (NIST SP800-53 Rev3), HIPAA - Health Insurance Portability and Accountability Act of 1996 (NIST Publication 800-66) and the SANS Critical Security Controls (Control 3).

In order to ensure file integrity and to mitigate the malware risk, Junos OS Evolved runs IMA, and a companion mechanism: the Extended Verification Module (EVM). These open source protections are part of a set of Linux Security Modules that are industry-standard and consistent with the trust mechanisms specified by the Trusted Computing Group.

Juniper Networks applies digital signatures to Junos OS Evolved files, and allows customers to apply digital signatures as well. Digital signatures are created using protected private keys, and then verified using public keys embedded into one or more keyrings.

The IMA/EVM subsystem protects the system by performing run-time checks. If a file fails verification, it is not opened or executed.

That means that unverified software is blocked on a device running Junos OS Evolved.

Running Third-Party Applications in Containers

IN THIS SECTION

To run your own applications on Junos OS Evolved, you have the option to deploy them as a Docker container. The container runs on Junos OS Evolved, and the applications run in the container, keeping them isolated from the host OS. Containers are installed in a separate partition mounted at **/var/extensions**. Containers persist across reboots and software upgrades.

NOTE: Docker containers are not integrated into Junos OS Evolved, they are created and managed entirely through Linux by using Docker commands. For more information on Docker containers and commands, see the official Docker documentation: https://docs.docker.com/get-started/

Containers have default limits for the resources that they can use from the system:

- **Storage** – The size of the **/var/extensions** partition is platform driven: 8GB or 30% of the total size of /var, whichever is smaller.
- **Memory** – Containers have no default physical memory limit. This can be changed.

- **CPU** – Containers have no default CPU limit. This can be changed.

> **NOTE**: You can modify the resource limits on containers if necessary. See "Modifying Resource Limits for Containers" on page 87.

Deploying a Docker Container

To deploy a Docker container:

1. Start the Docker service bound to a VRF (for example `vrf0`). For Junos OS Evolved Releases 23.4R1 and earlier, all the containers managed by this Docker service will be bound to this Linux VRF. For Junos OS Evolved Release 24.1R1 and later, we recommend binding specific tasks within the container to a VRF. See "Selecting a VRF for a Docker Container" on page 85 for more details.

```
[vrf:vrf0] user@host_RE0:~# systemctl start docker@vrf0
```

2. Set the Docker socket for the client by configuring the following environment variable:

```
[vrf:vrf0] user@host_RE0:~# export DOCKER_HOST=unix:///run/docker-vrf0.sock
```

3. Import the image.

> **NOTE**: The URL for the `import` command needs to be changed for different containers.

```
[vrf:vrf0] user@host_RE0:~# docker import http://198.0.2.2/lxc-images/images/pyez_new/2.1.9/
amd64/default/20190225_19:53/rootfs.tar.xz
```

4. Make sure the image is downloaded, and get the image ID.

```
[vrf:vrf0] user@host_RE0:~# docker image ls
REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
pyez                latest              738c70533604        59 seconds ago      491MB
```

5. Create a container using the image ID and enter a bash session in that container.

```
[vrf:vrf0] user@host_RE0:~# docker run -it --name pyez1 --network=host 738c70533604 bash
```

6. Create a container with Packet IO and Netlink capablity using the image ID and enter a `bash` session in that container.

```
[vrf:vrf0] user@host_RE0:~# docker run --rm -it --network=host --ipc=host --cap-add=NET_ADMIN
--mount source=jnet,destination=/usr/evo --device=/dev/jtd0 -v /dev/mcgrp:/dev/mcgrp -v /dev/
shm:/dev/shm --env-file=/run/docker-vrf0/jnet.env --dns ::1 debian:stretch ip link
738c70533604 bash
```

NOTE: Docker containers are daemonized by default unless you use the `-it` argument.

Managing a Docker Container

Docker containers are managed through standard Docker Linux workflow. Use the `docker ps`, `ps` or `top` Linux commands to show which Docker containers are running, and use Docker commands to manage the containers. For more information on Docker commands, see: https://docs.docker.com/engine/reference/commandline/cli/

NOTE: Junos OS Evolved high availability features are not supported for custom applications in Docker containers, If an application has high availability functionality then you should run the application on each RE to ensure it can sync itself. Such an application will need to have the required business logic to manage itself and communicate with all instances.

Enabling Netlink or PacketIO in a Container

You need to provide additional arguments to Docker commands if your container requires extra capabilities like Netlink or PacketIO. You will also need to enable `nlsd` service for enabling Netlink functionality on certain releases. The following example shows how to activate Netlink or PacketIO capabilities for a container by adding arguments to a Docker command:

1. Create a read-only name persistent volume upon starting Docker services. Mounting the `jnet` volume will mount required libraries needed for PacketIO and Netlink functionality over WAN/data ports:

```
--mount source=jnet,destination=/usr/evo
```

2. Share the host's Network and IPC namespace with the container. Containers requiring PacketIO and Netlink functionality over WAN/data ports will need to be in the host Network and IPC namespace:

```
--network=host --ipc=host
```

3. Automatically start the container upon system reboot:

```
--restart=always
```

4. Enable net admin capability, which is required by Netlink and PacketIO libraries:

```
--cap-add=NET_ADMIN
```

5. Enable the environmental variables required for Netlink and PacketIO over WAN/data ports:

```
--env-file=/run/docker/jnet.env
```

6. Mount the jtd0 device from host to the container to help with PacketIO:

```
--device=/dev/jtd0
```

7. Mount the host's **/dev/shm** directory to the container for Netlink and PacketIO over WAN/data ports:

```
-v /dev/shm:/dev/shm
```

8. If multicast group management is required by the container application, mount the **/dev/mcgrp** directory from the host to the container:

```
-v /dev/mcgrp:/dev/mcgrp
```

9. After Junos OS Evolved release 24.1R1, containers in the host network namespace that want to have DNS resolution will need to pass the `--dns ::1` option to the `docker run` command. This is not required for Junos OS Evolved release 23.4 and earlier:

```
--dns ::1
```

10. If your container requires Netlink related processing, then you also need to enable the Netlink asynchronous API (`nlsd`) process in Junos OS Evolved with the following CLI configuration:

```
[edit]
user@host# set system processes nlsd enable
```

NOTE: Native Linux or container-based applications that require PacketIO and Netlink functionality should be dynamically linked. We recommend using Ubuntu based Docker containers, as they are the only containers that are officially qualified by Juniper Networks. Ubuntu-based containers should use the `glibc` compatible with the base Junos Evolved OS `glibc`.

Selecting a VRF for a Docker Container

For Junos OS Evolved Releases 23.4R1 and earlier, containers inherit virtual routing and forwarding (VRF) from the Docker process. In order to run containers in a distinct VRF, a Docker process instance needs to be started in the corresponding VRF. The `docker@`*`vrf`*`.service` instance allows for starting a process in the corresponding VRF. If the VRF is unspecified, the VRF defaults to `vrf0`.

The `docker.service` runs in `vrf:none` by default.

For Junos OS Evolved Releases 24.1R1 and later, we recommend binding a specific task within the container to a specific Linux VRF by using the `ip vrf exec` *task* command. This requires the container to be started with the option `--privileged`, and the container needs to have a compatible version of `iproute2` installed. The container should also share the network namespace with the host. You can also use the

socket option SO_BINDTODEVICE to bind the socket for a specific task or application within the container to a specific Linux VRF device, in which case iproute2 is not needed.

The ip vrf show command lists all available Linux VRFs. If you choose to bind the sockets for a task within the container to a VRF using iproute2, we recommend overwriting some env variables by using --env-file=/run/docker-vrf0/jnet.env, so libnli.so won't be preloaded to avoid it interfering with iproute2.

You can launch a container and bind the socket associated with the container's task to the default vrf vrf0 with the following commands:

```
[vrf:none] user@host:~# docker -H unix:///run/docker-vrf0.sock run --rm -it --privileged --
network=host --ipc=host --cap-add=NET_ADMIN --mount source=jnet,destination=/usr/evo --
device=/dev/jtd0 -v /dev/mcgrp:/dev/mcgrp -v /dev/shm:/dev/shm --env-file=/run/docker-vrf0/
jnet.env --dns ::1 debian:stretch bash

# explicitly preload libsi.so and avoid libnli.so. Bind ping's socket to vrf0 (default) VRF
[vrf:none] user@host: my-container/# LD_PRELOAD=libsi.so.0 ip vrf exec vrf0 ping 1.2.3.4
```

With this approach, different sockets associated with different tasks within the container can be associated with different VRFs instead of all sockets bound to just one VRF.

The Docker process for a specific VRF listens on corresponding socket located at **/run/docker-*vrf*.sock**.

This is the VRF as seen on the Linux and not the Junos OS Evolved VRF. The utility evo_vrf_name (available starting in Junos OS Evolved release 24.1) can be used to find the Linux VRF that corresponds to a Junos OS Evolved VRF.

The Docker client gets associated with the VRF specific Docker process by use the following arguments:

```
--env-file /run/docker-vrf/jnet.env
--host unix:///run/docker-vrf.sock or export DOCKER_HOST=unix:///run/docker-vrf.sock
```

For example, to run a container in vrf0 enter the following Docker command and arguments:

```
[vrf:none] user@host:~# docker -H unix:///run/docker-vrf0.sock run --rm -it --network=host --
ipc=host --cap-add=NET_ADMIN --mount source=jnet,destination=/usr/evo --device=/dev/jtd0 -v /dev/
mcgrp:/dev/mcgrp -v /dev/shm:/dev/shm --env-file=/run/docker-vrf0/jnet.env --dns ::1
debian:stretch ip link
1002: et-01000000000: BROADCAST,MULTICAST,UP mtu 1514 state UP qlen 1
    link/ether ac:a:a:18:01:ff brd ff:ff:ff:ff:ff:ff
1001: mgmt-0-00-0000: BROADCAST,MULTICAST,UP mtu 1500 state UP qlen 1
    link/ether 50:60:a:e:08:bd brd ff:ff:ff:ff:ff:ff
```

```
1000: lo0_0: LOOPBACK,UP mtu 65536 state UP qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
```

NOTE: A container can only be associated to a single VRF.

Modifying Resource Limits for Containers

The default resource limits for containers are controlled through a file located at **/etc/extensions/platform_attributes**. You will see the following text upon opening this file:

```
## Edit to change upper cap of total resource limits for all containers.
## applies only to containers and does not apply to container runtimes.
## memory.memsw.limit_in_bytes = EXTENSIONS_MEMORY_MAX_MIB + EXTENSIONS_MEMORY_SWAP_MAX_MIB:-0
## please start extensions-cglimits.service to apply changes to CPU and Memory values here
## please restart var-extensions.mount to apply changes to partition resize here
## make sure the docker daemon is stopped before changing mount size
## For changing EXTENSIONS_FS_DEVICE_SIZE_MIB, please also remove file rm /var/extensions_fs
## make sure to create a backup before partition resize

## check current defaults, after starting extensions-cglimits.service
## $ /usr/libexec/extensions/extensions_cglimits get
## you can also set current values like this as an alternative to starting extensions-
cglimits.service
## $ /usr/libexec/extensions/extensions_cglimits set
## if you set one of the memory values, set the other one as well - mandated by cgroup


## device size limit will be ignored once extensionsfs device is created
#EXTENSIONS_FS_DEVICE_SIZE_MIB=
#EXTENSIONS_CPU_QUOTA_PERCENTAGE=
#EXTENSIONS_MEMORY_MAX_MIB=
#EXTENSIONS_MEMORY_SWAP_MAX_MIB=
```

To change the resource limits for containers, add values to the `EXTENSIONS` entries at the bottom of the file. Make sure to do this prior to starting the Docker process.

- `EXTENSIONS_FS_DEVICE_SIZE_MIB=` controls the maximum storage space that containers can use. Enter the value in megabytes. The default value is 8000 or 30% of the total size of **/var**, whichever is smaller.

Make sure to add this entry before starting the Docker process for the first time. If you need to change this value later on, you will need to delete the existing partition, which can lead to loss of data on this partition. If this storage partition needs to be changed after the Docker service has already been started then Docker process needs to be stopped first with the `systemctl stop docker` command, and the existing partition can be deleted using the `systemctl stop var-extensions.mount` command followed by the `rm /var/extensions_fs` command. Once this attribute has been changed, start the Docker process again and the new partition with the specified size will be created. You can also restart `var-extensions.mount` with the `systemctl restart var-extensions.mount` command to achieve the same result. We suggest taking a backup of the partition to avoid losing important data. We do not recommend increasing this value beyond 30% of the **/var** partition as this can affect the normal function of Junos OS Evolved.

- `EXTENSIONS_CPU_QUOTA_PERCENTAGE=` controls the maximum CPU usage that containers can use. Enter a value as a percentage of CPU usage. The default value is 20% but can vary depending on the platform.

- `EXTENSIONS_MEMORY_MAX_MIB=` controls the maximum amount of physical memory that containers can use. Enter the value in megabytes. The default value is 2000 but it can vary depending on the platform. If this needs to be modified, the swap value `EXTENSIONS_MEMORY_SWAP_MAX_MIB=` should also be specified. Note that Linux `cgroup` does not allow unreasonable values to be set for memory and CPU limits. If the values set are not reflected in the `cgroup`, the most likely reason is that the values are wrong (possibly very high or very low).

- `EXTENSIONS_MEMORY_SWAP_MAX_MIB=` controls the maximum amount of swap memory that containers can use. Enter the value in megabytes. The default value is 15% of available swap space, but it can vary depending on the platform. Both the `EXTENSION_MEMORY_MAX_MIB=` and `EXTENSIONS_MEMORY_SWAP_MAX_MIB=` should be set if either one is being modified. Recommended value for swap is 15% of `EXTENSION_MEMORY_MAX_MIB=`. The actual `cgroup` value for swap would be `EXTENSION_MEMORY_MAX_MIB` + `EXTENSIONS_MEMORY_SWAP_MAX_MIB`.

By default these are set to platform-specific values, so we recommend setting the values before starting containers.

CAUTION: Before modifying the resource limits for containers, be aware of the CPU and memory requirements for the scale you have to support in your configuration. Exercise caution when increasing resource limits for containers to prevent them from causing a strain on your system.

Running Third-Party Applications Natively With Signing Keys

IN THIS SECTION

Signing Keys Overview

Starting in Junos OS Evolved Release 22.4R1, you can generate signing keys and use them to sign executable files or shared objects. Signing an executable file gives it permission to run on the device, allowing you to approve trusted applications to run alongside authorized Juniper Networks software.

Junos OS Evolved requires users to sign all files that will be mapped into memory for execution. This includes the following file types:

- Executable and Linkable Format (ELF) files
- Shared Objects (.so) files

The following types of files do not need to be signed:

- Docker containers
- Applications inside containers
- Scripts

NOTE: Although scripts don't need to be signed, they do need to be passed through a signed interpreter for execution. Junos OS Evolved comes installed with signed Python 2 and Python 3 interpreters that can be used through the `python` *`script-name`* shell command.

Signing keys are controlled by a Linux subsystem called Integrity Measurement Architecture (IMA). IMA policy consists of rules that define which actions needs to be taken before a file can be executed. IMA measurement policy will measure and store a file's hash, and IMA appraisal policy will make sure that the file has a valid hash or digital signature. IMA will only allow a file to run if this validation succeeds. For more information about IMA, see "Protecting the Integrity of Junos OS Evolved with IMA" on page 80.

Signing keys are stored in the *system keystore*, and the certificates used the verify signing keys are stored in the *IMA extended keyring*. Keep reading to learn how to generate, import, view, and use signing keys.

Generating Signing Keys

IN THIS SECTION

Keys can be generated through the OpenSSL command-line or a OpenSSL configuration file.

Generating Signing Keys Using the OpenSSL Command-Line

The following example OpenSSL command can be used to generate signing keys:

```
openssl req -new \
    -newkey rsa:3072 \       # Create an RSA 3072 key
    -x509 \                        # Need an X509 certificates
    -sha256 \                      # Strong hashing algorithm
    -nodes \                       # No encrypted private-key
    -out ima-cert.x509 \     # Name of the certificate file
    -outform DER \              # Key in DER format
    -keyout privkey.pem \    # Name of the private key
```

This command will generate 2 files:

1. `privkey.pem` - The PEM encoded private key that can be used to sign executable files.
2. `ima-cert.x509` - The DER encoded certificate to be loaded into the IMA extended keyring.

NOTE: The OpenSSL command-line is limited in its functionality. It does not allow you to set values for the X509v3 extensions. All keys generated using the command above can be used as Certificate Authorities (CAs), and therefore can be used to sign other certificates. To prevent this, we can use an OpenSSL Configuration File.

Generating Signing Keys Using an OpenSSL Configuration File

Create a file named `ima-x509.cnf` and paste the following contents:

```
# Begining of ima-x509.cnf
[ req ]
default_bits = 2048
distinguished_name = custom_distinguished_name
prompt = no
string_mask = utf8only
x509_extensions = custom_exts

[ custom_distinguished_name ]
O = Juniper Networks, Inc.
CN = IMA extended signing key
emailAddress = john.smith@juniper.net

[ custom_exts ]
basicConstraints=critical,CA:FALSE
keyUsage=digitalSignature
subjectKeyIdentifier=hash
authorityKeyIdentifier=keyid
# EOF
```

After the configuration file is created, use the following OpenSSL command to create the `ima-privkey.pem` and `ima-cert.x509` files:

```
openssl req -new \
        -nodes \
        -utf8 \
        -sha1 \
        -days 36500 \
        -batch \
        -x509 \
        -config ima-x509.cnf \
```

```
        -outform DER -out ima-cert.x509 \
        -keyout ima-privkey.pem
```

The private key file `ima-privkey.pem` is used to generate signing keys, and the certificate file `ima-cert.x509` is used to verify the signature. Both files are used during the process of importing signing keys into the system keystore and IMA extended keyring.

Importing Signing Keys into the System Keystore and IMA Extended Keyring

Signing keys need to be imported into the system keystore prior to use. Keys that are imported into the system keystore are automatically imported into the IMA extended keyring. Keys will be imported on both Routing Engines.

To import a signing key into the system keystore, use the `request security system-keystore import` command with the following 2 mandatory arguments:

1. `key-name` - A unique name for the key
2. `x509-cert` - Path to the DER encoded certificate file

The following example command will create a key named **ima-test-key** by using the certificate file `ima-cert.x509`:

```
user@host> request security system-keystore import key-name ima-test-key x509-cert ima-cert.x509

  Key Name:               ima-test-key
  X509 Cert Path:         /etc/ima-ext/ima-test-key/ima-cert.x509
  Key SKI:                b71b35e380517cd224b46072dadeb6c53e0a58a1
```

When the key is successfully imported into the `system-keystore` you will see the above output displaying the name of the key, the path to the certificate on disk, and the Subject Key Identifier (SKI) for the key. You can check if this SKI matches with the key loaded into the IMA Extended keyring with the following command:

```
user@host> show security integrity extended-keyring

Keyring
 351716837 ---lswrv      0     0  keyring: ima_ext
```

```
 684930381 --als--v      0     0   \_ asymmetric: Juniper Extended Signing Key:
b71b35e380517cd224b46072dadeb6c53e0a58a1
```

Viewing the System Keystore and IMA Extended Keyring

You can view the contents of the system keystore and the IMA extended keyring through Junos OS Evolved CLI `show` commands.

Use the `show security integrity system-keystore` command to view the available signing keys in the system keystore:

```
user@host> show security integrity system-keystore

  Available signing keys:
  ---
  Key Name:               ima-test-key
  X509 Cert Path:         /etc/ima-ext/ima-test-key/ima-cert.x509
  Key SKI:                b71b35e380517cd224b46072dadeb6c53e0a58a1
  ---
  Key Name:               test-key1
  X509 Cert Path:         /etc/ima-ext/test-key1/ima-cert.x509
  Key SKI:                332f173d61bba03fed5399a609523cbd3cfe66b3
  ---
  Key Name:               test-key2
  X509 Cert Path:         /etc/ima-ext/test-key2/ima-cert.x509
  Key SKI:                26ebafd58b54f7b8b530d0311503fd84873ee754
  ---
```

The information in the Key SKI field can be used to map these keys to the IMA extended keyring.

Use the `show security integrity extended-keyring` command to view the contents of the IMA extended keyring:

```
user@host> show security integrity extended-keyring

Keyring
 351716837 ---lswrv      0     0  keyring: ima_ext
 684930381 --als--v      0     0   \_ asymmetric: Juniper Extended Signing Key:
b71b35e380517cd224b46072dadeb6c53e0a58a1
```

```
 316767440 --als--v      0     0   \_ asymmetric: Juniper Extended Signing Key:
26ebafd58b54f7b8b530d0311503fd84873ee754
 950431262 --als--v      0     0   \_ asymmetric: Juniper Extended Signing Key:
332f173d61bba03fed5399a609523cbd3cfe66b3
```

How to Sign Applications

After a signing key has been imported into the system keystore, it can be used to sign executable binaries.

Use the `request security integrity measure file` *`filename`* `key` *`key-name`* command to sign a file.

The following example command shows a file named **ima-test** being signed by a key named **ima-test-key**:

```
user@host> request security integrity measure file ima-test key ima-test-key
Successfully signed file /data/var/home/root/ima-test
```

You can verify that your file was successfully signed by using the `request security integrity appraise file` *`filename`* `key` *`key-name`* command, as follows:

```
user@host> request security integrity appraise file ima-test key ima-test-key
File /data/var/home/root/ima-test has a valid IMA signature
```

If the file was not signed properly, the following message will display:

```
user@host> request security integrity appraise file ima-test key ima-test-key
    warning: IMA signature verification failed for /data/var/home/root/ima-test using ima-test-
key
    IMA appraisal for /data/var/home/root/ima-test failed.
```

After a file has been signed, it can be run natively on your Junos OS Evolved device.

Managing Third-Party Applications

IN THIS SECTION

Using Intercept Libraries

IN THIS SECTION

Junos OS Evolved can run third-party applications because it runs on native Linux. There are some differences between the way Linux displays requested network topology information such as interface and route data and the way Junos OS displays this information. The CLI is designed to overcome these differences. But typically, third-party applications running on native Linux obtain this information directly from the native Linux sources using shell commands.

Junos OS Evolved uses an intercept mechanism that redirects shell requests for network topology information to a space where the information can be obtained from Junos OS. This intercept mechanism is accomplished through intercept libraries, `libsi.so` and `libnli.so`, that you preload. After you preload the intercept library, certain types of requests are intercepted and show Junos OS information.

The intercept libraries are optional; they are needed only if the application requires the APIs mentioned in Table 11 on page 96:

Table 11: APIs That Require Intercept Libraries

API	Description
Packet IO and Linux socket APIs	Ability to send and receive packets over management and/or data interfaces. Standard libc, such as send, receive, listen.
rtnetlink	Ability to use rtnetlink to query networking state like interfaces, routes.
netdevice	Ability to configure network devices.
proc	Ability to query kernel data structures using standard interfaces provided by Linux kernel.
Junos APIs	Ability to access Juniper North Bound APIs - NetConf/JET/Telemetry.

NOTE: For more information on Juniper Northbound APIs, see the following:

- Overview of JET APIs
- NETCONF XML Management Protocol and Junos XML API Overview
- Overview of the Junos Telemetry Interface

NOTE: Junos OS Evolved Release 20.1R1 supports the following features:

- Use the `set system netlink-async-mode` configuration to enable NETLINK_ROUTE asynchronous notifications. This feature is disabled by default. Use `show nsld mode` to show the current netlink asynchronous mode.
- `SIOCETHTOOL` ioctl, which can be used by other applications.
- Multipath next-hop route information through netlink route attributes.

Example of a Preloaded Linux Command

An example how the preload directive works follows using the command `ifconfig`, which displays interfaces.

If you preload the `ifconfig` command with the intercept library, Junos OS interface information is returned. Notice that the intercept library only translates logical interfaces. In this example, because

there are logical interfaces only on lo0 and re0:mgmt-0.0, the output displays only these two interfaces for the preloaded `ifconfig` command.

```
[vrf:none] user@host_RE0:~# LD_PRELOAD=libnli.so ifconfig
lo0_0     Link encap:Ethernet  HWaddr 00:00:00:00:00:00
          inet addr:128.102.224.244  Mask:255.255.255.255
          inet6 addr: abcd::128:102:224:244/128 Scope:Global
          inet6 addr: fe80::5668:a6f0:6e:b79/128 Scope:Link
          UP LOOPBACK RUNNING  MTU:65535  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

mgmt-0-00-0000 Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:79
          inet addr:10.102.224.244  Bcast:10.102.239.255  Mask:255.255.240.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:1103938 errors:0 dropped:0 overruns:0 frame:0
          TX packets:1905 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:85166899 (81.2 MiB)  TX bytes:243066 (237.3 KiB)
```

You can get the same results by running jbash, which is a shell provided with Junos OS Evolved that preloads `libnli.so` and `libsi.so` by default.

CAUTION: Only use jbash to get the network state information. Don't use jbash as your default shell.

If you issue the command without preloading it with the intercept library, the output shown is from Linux. Notice that the following output is longer than that from Junos OS. Linux does not make the distinction between physical interfaces and logical interfaces that the Junos CLI does.

```
[vrf:none] user@host_RE0:~# ifconfig -a
eth0      Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:79
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:1608443 errors:44 dropped:0 overruns:0 frame:44
          TX packets:2652 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:150837081 (143.8 MiB)  TX bytes:341675 (333.6 KiB)

eth1      Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:7e
```

```
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:9600  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:5 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:418 (418.0 B)

eth2      Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:83
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:9600  Metric:1
          RX packets:907046 errors:0 dropped:0 overruns:0 frame:0
          TX packets:926156 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:70342248 (67.0 MiB)  TX bytes:119965968 (114.4 MiB)

eth3      Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:8d
          BROADCAST MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

eth4      Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:9d
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:1607983 errors:44 dropped:0 overruns:0 frame:44
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:150335380 (143.3 MiB)  TX bytes:0 (0.0 B)

ingvrf    Link encap:Ethernet  HWaddr 12:6e:39:d6:5a:64
          UP RUNNING NOARP MASTER  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

iri       Link encap:Ethernet  HWaddr 4e:a2:93:c0:ac:67
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP RUNNING NOARP MASTER  MTU:65536  Metric:1
          RX packets:2199380 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2216726 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:674308465 (643.0 MiB)  TX bytes:735412009 (701.3 MiB)
```

```
jtd0      Link encap:Ethernet  HWaddr 06:50:4e:19:c6:c5
          inet6 addr: fe80::450:4eff:fe19:c6c5/64 Scope:Link
          UP BROADCAST RUNNING NOARP  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

jtdrop    Link encap:Ethernet  HWaddr ba:d0:d0:72:7e:eb
          inet6 addr: fe80::b8d0:d0ff:fe72:7eeb/64 Scope:Link
          UP BROADCAST RUNNING NOARP  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:3 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:210 (210.0 B)

jtdv0     Link encap:Ethernet  HWaddr 56:2a:0c:39:f1:5d
          inet6 addr: fe80::542a:cff:fe39:f15d/64 Scope:Link
          UP BROADCAST RUNNING NOARP  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:280 (280.0 B)

jtdv50    Link encap:Ethernet  HWaddr 56:5e:67:d6:e2:d2
          inet6 addr: fe80::545e:67ff:fed6:e2d2/64 Scope:Link
          UP BROADCAST RUNNING NOARP  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:4 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:280 (280.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:32 errors:0 dropped:0 overruns:0 frame:0
          TX packets:32 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:2144 (2.0 KiB)  TX bytes:2144 (2.0 KiB)

mgmt_junos Link encap:Ethernet  HWaddr 6a:75:4b:20:d0:4e
          inet addr:127.0.0.1  Mask:255.0.0.0
```

```
          inet6 addr: ::1/128 Scope:Host
          UP RUNNING NOARP MASTER  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

sit0      Link encap:UNSPEC  HWaddr 00-00-00-00-30-30-30-00-00-00-00-00-00-00-00-00
          NOARP  MTU:1480  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

tunl0     Link encap:IPIP Tunnel  HWaddr
          NOARP  MTU:1480  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

vcb       Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:83
          inet addr:176.1.1.1  Bcast:0.0.0.0  Mask:255.255.255.252
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:9600  Metric:1
          RX packets:907043 errors:0 dropped:0 overruns:0 frame:0
          TX packets:924347 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:57643466 (54.9 MiB)  TX bytes:118743890 (113.2 MiB)

vfb       Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:7e
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:9600  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

vib       Link encap:Ethernet  HWaddr 3e:fb:67:87:16:1a
          inet addr:128.0.0.4  Bcast:0.0.0.0  Mask:255.0.0.0
          inet6 addr: fe80::3cfb:67ff:fe87:161a/64 Scope:Link
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:74 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
```

```
          RX bytes:0 (0.0 B)  TX bytes:3420 (3.3 KiB)

vmb0      Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:79
          inet addr:10.102.224.244  Bcast:0.0.0.0  Mask:255.255.240.0
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:1602504 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2645 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:124666750 (118.8 MiB)  TX bytes:340201 (332.2 KiB)

vmb1      Link encap:Ethernet  HWaddr 56:68:a6:6e:0b:9d
          UP BROADCAST RUNNING PROMISC MULTICAST  MTU:1500  Metric:1
          RX packets:1602784 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:124008554 (118.2 MiB)  TX bytes:0 (0.0 B)

vrf0      Link encap:Ethernet  HWaddr ca:12:9e:40:a8:01
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP RUNNING NOARP MASTER  MTU:65536  Metric:1
          RX packets:124413 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2597 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:19087613 (18.2 MiB)  TX bytes:338185 (330.2 KiB)

vrf50     Link encap:Ethernet  HWaddr 06:de:d7:3d:18:be
          UP RUNNING NOARP MASTER  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

Interface Name Translation

One limiting factor to using this intercept mechanism is that Linux interface naming is incompatible with the Junos OS interface naming. Linux supports 15-byte interface names (15 + null-character); network interface names that exceed this limit are truncated in outputs. Junos OS logical interface names could be longer than 15 bytes, for example, `et-0/0/10:2.32767`.

To work around this difference, Junos OS Evolved uses a translation rule (see Table 12 on page 102) to render logical interface names in a Linux-compliant format. The translation renders a format such as

name-fpcSlot/picSlot/port:channelId.subUnit to nn-ffpttccssss. Using interface names translated according to this rule, third-party applications can effectively fetch the topology information from Junos OS.

Only translation of logical interface names is supported, and translation of both channelized and nonchannelized logical interface names is supported.

Table 12: Translation Rule for Interface Names

Value	Description	Allotted Space (in bytes)	Range
nn	mapped name bytes	2	
ff	fpc in hex	2	0-255
p	pic in hex	1	0-15
tt	port number in hex	2	0-255
cc	channel in hex; use “xx” if not present	2	0-255
ssss	subunit in hex	4	0-65535

Except for management interfaces, if the logical interface name does not have a hyphen (-) in it, the dot (.) in the name is changed to an underscore (_), for example: ifdname.subunit gets translated to ifdname_subunit.

For management interfaces, reX:mgmt-Y.Z translates to mgmt-x-yy-zzzz, where x, yy, zzzz are in hex-padded with 0 for a fixed length. And the reverse translation happens on the same lines.

See Table 13 on page 102 for examples of Junos logical interface names and their Linux-compliant forms.

Table 13: Examples of Translated Logical Interface Names

Junos Logical Interface Name	Translated Linux-Compliant Interface Name
et-1/2/3.4	et-01203xx0004

Table 13: Examples of Translated Logical Interface Names *(Continued)*

Junos Logical Interface Name	Translated Linux-Compliant Interface Name
ge-1/2/3.32	ge-01203xx0020
et-1/15/3.4	et-01f03xx0004
et-1/2/255:6.7	et-012ff060007
et-1/2/4:5.32767	et-01204057fff
re0:mgmt-1.2	mgmt-0-01-0002
ae0.1	ae0_1
irb0.11	irb0_11

When accessing Junos OS states by preloading `libnli.so`, the interface name in the output is shown as a translated Linux-compliant interface name. You must also use the translated Linux-compliant interface name when using it as an argument in a command. The translated `et-01000000000` interface name is used as an argument in the following example:

```
[vrf:none] user@host_RE0:~# LD_PRELOAD=libnli.so ifconfig et-01000000000
et-01000000000 Link encap:Ethernet  HWaddr 5c:31:b0:35:01:ff
          inet addr:20.20.20.24  Bcast:20.20.20.255  Mask:255.255.255.0
          inet6 addr: 2000:200:20::2/64 Scope:Global
          inet6 addr: fe80::5e31:b0ff:fe35:1ff/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1514  Metric:1
          RX packets:312 errors:0 dropped:0 overruns:0 frame:0
          TX packets:156 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1
          RX bytes:31004 (30.2 KiB)  TX bytes:21346 (20.8 KiB)
```

Caveats for the Intercept Feature

This intercept feature supports read-only requests. Any write request returns an error.

Representation of certain Junos network state may not be mappable to Linux equivalents. In these cases, the data is either be omitted or re-mapped to a comparable Linux model. For example, Junos OS Evolved supports a rich suite of nexthop types such as `composite` or `unilist` that do not have comparable implementations in native Linux.

Third-party applications that are linked statically cannot be intercepted and, therefore, are not supported by this feature.

Removing Third-Party Applications

There are several methods for removing third-party applications. The method you should use is based on how you installed the application.

- If a third-party application was installed with the `request system software add` command, then you can remove the same application by using the `request system software delete` command.

```
user@host> request system software delete ima-test
Removing version 'ima-test'.
Software ... done.
Data ... done.
Version 'ima-test' removed successfully.
```

- The first step in removing these applications is to unlink the key with the `request security system-keystore unlink` *key* command.

```
user@host> request security system-keystore unlink key
```

Next, remove any binaries that you installed for the application with the `rm -f /path/to/binary1 /path/to/binary2` shell command.

```
user@host:~# rm -f /path/to/binary1 /path/to/binary2
```

- If a third-party application was installed through a Docker container, then use the following Docker command to remove the container:

```
docker rm container-name
```

Building Third-Party Applications

IN THIS SECTION

Junos OS Evolved supports packages of signed third-party applications developed in C, C++, and Python with the JET SDK for Junos OS Evolved. The Junos OS Evolved application manager (`SysMan`) or the Linux system manager (`systemd`) controls these third-party applications based on the nature and usage of the application.

JET SDK for Junos OS Evolved

IN THIS SECTION

Before building a third-party application to run on your device, you must first generate signing keys to give your application permission to run. See "Generating Signing Keys" on page 90 for more information.

Junos OS Evolved release 22.4R1 and later versions support the JET SDK for Junos OS Evolved on the following platforms:

Table 14: JET SDK for Junos OS Evolved Supported Platforms

ACX Series	PTX Series	QFX Series
ACX7100-32C	PTX10001-36MR	QFX5130-32CD
ACX7100-48L	PTX10003	QFX5130-48C
ACX7509	PTX10004	QFX5220
	PTX10008	
	PTX10016	

Downloading the JET SDK and JET Toolkit

Before you begin building a third-party application, download and install the JET SDK for Junos OS Evolved and the JET Toolkit for Junos OS Evolved. You can find these files on the Juniper Extension Toolkit (For Junos Evolved) page:

- The JET SDK for Junos OS Evolved: **jet-junos-evo-sdk-*release*-EVO.deb**
- The JET Toolkit for Junos OS Evolved: **jet-junos-evo-toolkit-*release*-EVO.tar.gz**

Installing the JET SDK and JET Toolkit for Junos OS Evolved

After downloading the JET Toolkit for Junos OS Evolved, unpack the tar file and extract the `Jet-evo` utility from the package.

NOTE: Starting in Junos OS Evolved release 23.2R1 and later you can also extract the `Jet-evo-bundle-iso` utility for creating bundled ISOs. For more information on bundled ISOs, see "Creating a Bundled ISO" on page 118.

After downloading the SDK, install and source it. The JET SDK for Junos OS Evolved is a Debian package that you can install on Debian-based Linux distributions like Ubuntu and Debian. Use the following Linux command to install the JET SDK for Junos OS Evolved release 22.4R1:

```
user@host:~$ dpkg -i jet-junos-evo-sdk-22.4R1.10-EVO.deb
```

The `dpkg` command will install the SDK into the **/opt/jnpr/sdk/3.0.2-31** folder.

Next, you need to source the SDK for your third-party package. Use the following commands to source the JET SDK for Junos OS Evolved for a package in Junos OS Evolved release 22.4R1:

```
user@host:~/package-name$ source /opt/jnpr/sdk/3.0.2-31/environment-setup-core2-32-poky-linux
user@host:~/package-name$ source/opt/jnpr/sdk/3.0.2-31/environment-setup-core2-64-poky-linux
user@host:~~/package-name$ source /opt/jnpr/sdk/3.0.2-31/environment-setup-x86-pokymllib32-linux
```

SysMan and systemd Controlled Applications

The native Junos OS Evolved application manager (`SysMan`), or the Linux system manager (`systemd`) can control third-party applications. `SysMan` controlled applications can take advantage of Junos OS Evolved's distributed infrastructure and run across multiple nodes. Meanwhile, `systemd` managed applications can only run on a single node, so `SysMan` is the preferred application manager in most cases.

`SysMan` and `systemd` managed applications use different methods to define policy through service files. Applications managed through `SysMan` use `.yaml` files to define policy and assign services. See ".yaml Files" on page 111 for more information.

Applications managed through `systemd` define policy and assign services through `.service` files. See "Service Files" on page 110 for more information.

When routing engine switchover occurs, `SysMan` managed applications will start automatically on the new primary Routing Engine, but `systemd` managed applications will continue running on the original Routing Engine. We recommend using `SysMan` controlled applications when possible on dual Routing Engine systems.

Folder Structure for Third-Party Applications

IN THIS SECTION

Third-party application packages follow a specific folder structure in Junos OS Evolved.

root-fs Folder Structure

The `root-fs` folder contains the following folders:

- **usr/sbin** (mandatory): Contains the binary executable file for the application.
- **usr/lib64** (optional): Contains the necessary libraries for the application.
- **etc/sytemd/sytem** (optional): Contains `systemd` service unit files for `systemd` controlled applications (mandatory for `systemd` managed applications).
- **usr/conf** (optional): Contains `.yaml` files for policy generation (mandatory for `SysMan` managed applications).

You can find the following optional folders outside the `root-fs` folder:

- **scripts** (optional): Contains the preinstall, post-install and pre-uninstall scripts.
- **etc/config** (optional): Contains application specific configurations.

Post-install Folder Structure

After you install the third-party package, it will store the files at the following paths by default:

- **/usr/sbin/**: Contains the binary executable files for applications in the package.
- **/usr/lib64/**: Contains the libraries for applications in the package.
- **/data/var/external/*current-evo-version*/**: Contains pre-install, post-install, and pre-uninstall script files, as well as `.bom`, `.sh`, `.fs` and `.ima` files for the applications in the package.
- **/etc/systemd/system/**: Contains `.service` files for setting application policies and attached services.
- **/usr/conf/**: Contains `.yaml` files for `SysMan` controlled applications.

NOTE: You can find the files for libraries and binaries in `read-only` folders. We do not recommend placing libraries and binaries in `read-write` enabled folders like **/etc** or **/var**.

Third-Party Application Files

IN THIS SECTION

Third-party application packages include several types of files. Keep reading for more information about the different file types:

Makefile

The Makefile is a necessary file for building and installing your third-party application. The Makefile needs to include the paths for other files like the SRC file, configuration file, and `.yaml` file. It also controls the installation location of the necessary files.

SRC Files

SRC files contain the source code for your application. You can write SRC files in C, C++ or Python. These files are necessary for the function of your third-party application.

Script Files

Script files include pre-install, post-install and pre-uninstall scripts. These optional files are shell scripts that you can customize to fit the needs of your application.

- Pre-install scripts run before installing your third-party package. These scripts are typically used for testing and checking various factors on your device. For example you could create a pre-install script to check the version of Junos OS Evolved that is running before starting installation.
- Post-install scripts run after installing your third-party package. These scripts contain that commands to run after finishing installation. For example, creating additional log files or a logging directory for your package.
- Pre-uninstall scripts run before uninstalling your third-party package. These scripts are typically used to clean up folders and files created during the installation of your third-party package.

NOTE: All scripts must return zero upon successful execution and nonzero upon failure.

Scripts can be created in any folder. During the third-party package creation process with the `Jet-evo` tool, you can enter the paths to each type of script and they will be installed in the **/data/var/external/*current-evo-version*/** folder on your device. For more information on the `Jet-evo` tool, see "Jet-evo Tool Configuration" on page 114.

NOTE: If you are creating custom scripts, we recommend that you do not use any `bash` commands that will create additional CLI output. You can redirect CLI output to your own log file.

Service Files

Service files are mandatory files for `systemd` controlled applications. These files control application policy and determine which nodes and Routing Engines the application runs on.

You must place the service files inside the **etc/systemd/system/** folder in the `root-fs` directory for your package.

The following example is a `.service` file for an application named `Sample App`. This `.service` file defines the path to start the application, and the system state required to run the application.

```
[Unit]
Description="Sample App"
After=syslog.target sysman.service network.target network-online.target
Before=pre-evoapp-shutdown.service
OnFailure=failure_handler@%p.service

[Service]
EnvironmentFile=/usr/conf/system/system_env
TimeoutStopSec=60
WorkingDirectory=/usr/sbin
ExecStart=/usr/evo/evostart -d /usr/sbin -p %p /usr/bin/python /usr/sbin/sample/sample_app.py
ExecStop=/usr/sbin/exit_foo.py --bar
ExecStopPost=/usr/evo/exit_handler.sh %p
Restart=no
StartLimitBurst=3
StartLimitInterval=300
MemoryLimit=2G
```

```
RemainAfterExit=true
SyslogIdentifier=sample_app
```

The following fields are mandatory and should be used with the same syntax as the example file:

- After
- Before
- OnFailure
- WorkingDirectory
- ExecStart
- ExeStopPost

.yaml Files

.yaml files are mandatory files for SysMan controlled applications. These files are used to pass application specific policies that are used in the creation of systemd based service units and SysMan based policies during installation. .yaml files are also used to determine which nodes and Routing Engines the application runs on.

NOTE: If you include both .yaml and .service files for the same application in a package, then the .service file attributes will take precedence and the application will be treated as a sysman controlled application.

Third-party packages can have more than one service attached with the package. Each application controlled by SysMan must have a separate .yaml file for each attached service, with the service names as the .yaml filenames. .yaml filenames should match with the service names, rather the package name, because third-party package names can be different from the services included with the package.

You must place .yaml files inside the usr/conf folder in the root-fs directory for your package.

A .yaml file consists of multiple fields containing information about the corresponding application. See the following list for definitions of the .yaml file fields:

binpath Defines the path to the binary executable file.

exec-start Defines how to start the application, including the path and the arguments required for starting the application. This field corresponds to the ExecStart field in a systemd service unit.

working-dir Defines the path to the parent directory with binaries.

id Controls the name of the application. Should match the `.yaml` filename.

network Sets the network type, with values of `internal` or `external`. Applications that communicate outside the device should use the `external` value.

on-exit Controls the setting for restarting the application upon exit.

- `restart`: Controls if the application will be restarted upon exit with `true` or `false` values.

resource Sets the limits to system resources used by the application:

- `max-memory`: Controls the maximum amount of memory allowed to be consumed by each instance of application.
- `node-attribute`: Controls the type of node that the application will run on, with values such as `-re` and `fpc`.
  - *`node-type`*: Control the type of node for the action to run on, with values such as `-re` and `fpc`.
- `startup`: Controls if the application will be started after installation if a user defined Junos OS Evolved configuration is present with `true` or `false` values.
- `instances`: Controls the nodes that the application will be running on and maximum number of instances it can run.
  - `all_nodes`: Control if the application will run on all nodes with `true` or `false` values.
  - `max_num_of_instances`: Control the max number of instances that an application can run with a number value.

The following sample `.yaml` file shows the configuration for a sample application that will run on the primary Routing Engine with only 1 instance. Setting the `all_nodes` field to `false` prevents the application from running on all Routing Engines. Setting the `max_number_of_instances` field to `1` limits the application to 1 instance. Setting the `node-attribute` field to `-re` makes the application run on the Routing Engine. With this configuration, if the primary Routing Engine goes down, the application will automatically start on the backup Routing Engine.

```
description: "Sample app"
binpath: /usr/sbin/sample/sample_app.py
exec-start: "/usr/bin/python /usr/sbin/sample/sample_app.py"
working-dir: /usr/sbin
id: sample-app
network: internal
on-exit:
```

```
  restart: true
resource:
  instances:
    all_nodes: false
    max_num_of_instances: 1
  node-attributes:    - re
  max-memory: 2G
  startup: true
```

Creating a Third-Party Package

IN THIS SECTION

The Jet-evo tool creates third-party packages using the applications, binaries, and libraries created by the application developer. The process for creating a third-party package differs based on whether the Junos OS Evolved SysMan process or the Linux systemd process will manage the package. See below for more details on each specific scenario:

Create a SysMan Managed Package

External applications managed by SysMan need to have .yaml files for the services attached to the application.

1. Build and compile the application with C, C++, or Python using the JET SDK for Junos OS Evolved.
2. Create the necessary folders as explained in "Folder Structure for Third-Party Applications" on page 107.
3. Keep the binary executable in the **usr/sbin/** folder.
4. Keep the .yaml files in the **usr/conf/** folder and configuration files in the **etc/config/** folder.
5. Run the Jet-evo tool using options specific to your package. See "Jet-evo Tool Configuration" on page 114 for more information about the configuration options in the Jet-evo tool.

NOTE: You can optionally package your own `systemd` file along with the `.yaml` file if you need to use complex functions of `systemd` that cannot be included in a `.yaml` file. Place the service file in the **etc/systemd/system/** folder and `.yaml` file in the **usr/conf** folder.

Create a `systemd` Managed Package

External applications managed by `systemd` need to have a `.service` file for the services attached to the application.

1. Build and compile the application with C, C++, or Python using the JET SDK for Junos OS Evolved.
2. Create the necessary folders as explained in "Folder Structure for Third-Party Applications" on page 107.
3. Keep the binary executable in the **usr/sbin/** folder.
4. Keep the service file in the **etc/systemd/system/** folder.
5. Run the `Jet-evo` tool using options specific to your package. See "Jet-evo Tool Configuration" on page 114 for more information about the configuration options in the `Jet-evo` tool.

`Jet-evo` Tool Configuration

IN THIS SECTION

The `Jet-evo` tool is used to name your third-party package, set the version number, run installation scripts, and set the installation location for your third-party package. These variables are all controlled by options set when you run the `jet-evo` command:

```
$ ./Jet-evo -h
usage: Jet-evo [-h] -n NAME -r ROOT [-v VERSION] [-a ARCH] [-N NODE]
               [-i PREINSTALL] [-p POSTINSTALL] [-u PREUNINSTALL]
               [-d DIRECTORY] [-x] [-t] [-l LOGFILE] [-k KEY]
```

NOTE: See "Generating Signing Keys" on page 90 for information on generating a private key to use with the `Jet-evo` tool.

Required Arguments

The following arguments are required:

-n ***name*** Set the name of your third-party package.

-r ***root***: Define the root paths to the applications included in your package, separated by commas.

-v ***version***: Set a version number for your package.

Optional Arguments

The following arguments are optional:

-h Displays a help message explaining the `Jet-evo` fields.

-a ***architecture*** Choose the architecture targeted by your third-party package.

-n ***node*** Define the nodes targeted by your third-party package.

-i ***pre-install*** Specify file paths to pre-install scripts.

-p ***post-install*** Specify file paths to post-install scripts.

`-u` ***pre-uninstall*** Specify file paths to pre-uninstall scripts.

-d ***directory*** Set the target directory for installing your package.

-x Strips all debug files from the package.

-t Create a TAR file with all the output of the `Jet-evo` tool.

-l ***name*** Set the name and path of the packager logging file.

-k ***key*** Private key used for signing the third-party package.

Example Syntax

The following is an example of the syntax for the `jet-evo` command using a package named `sample_package` with version 1.0.1:

```
$ jet-evo -n sample_package -v 1.0.1 -t
            -i ./src/scripts/sample_package_preinstall
            -p ./src/scripts/sample_package_postinstall
            -u ./src/scripts/sample_package_preuninstall
            -d ./target/ -r ./install/
            -k ima-privkey.pem
```

Installing a Third-Party Package

After you have built or obtained a third-party application package, you can install it onto a Junos OS Evolved device. A package can install multiple applications together. The installation process will overwrite any previously installed application that exists in the package. We recommend keeping applications inside packages unique across different packages.

Before installing a third-party application, you must first install the appropriate signing keys and certificates on all REs. Installation will fail if signing keys are not properly generated. See "Generating Signing Keys" on page 90 for more information.

You can view installed keys by using the `show security integrity extended-keyring` command.

You can install third-party packages using the `request system software add` *`package-name`* command. For example:

```
request system software add sample_package.1.0.1.tgz
```

NOTE: Third-party packages can only be installed from the master Routing Engine.

After successfully installing a third-party package, the installation process will copy all associated files into the `/data/var/external/`*`current-evo-version`*`/` folder. The `show version` output will display all of the third-party packages on each Routing Engine for a particular software version under the `External Software` field:

```
user@host> show version
Hostname: sample_host
Model: ptx10008
```

```
Junos: 22.4I20221214083306-EVO
Yocto: 3.0.2
Linux Kernel: 5.2.60-yocto-standard-gae998d995
JUNOS-EVO OS 64-bit [junos-evo-install-ptx-x86-64-22.4I20221214083306-EVO]
External Software:
JET app sample_package 1.0.1
```

To display all the versions of Junos OS Evolved installed on your device, and the third-party packages installed for the current version on each node and each Routing Engine, you can use the `show software list` command:

```
user@host> show system software list | no-more
------------------------------
node: re0
------------------------------
Active boot device is primary: /dev/vda
List of installed version(s) :

    '-' running version
    '>' next boot version after upgrade/downgrade
    '<' rollback boot version
    '*' deleted JSU version

 >   junos-evo-install-ptx-x86-64-22.4I20221214085042 - [2022-12-14 09:14:39]
 -   junos-evo-install-ptx-x86-64-22.4I20221214083306 - [2022-12-14 08:58:24]
 <   junos-evo-install-ptx-x86-64-22.4I20221214072149 - [2022-12-14 08:04:20]
     junos-evo-install-ptx-x86-64-22.4I20221214055215 - [2022-12-14 06:39:46]

External Software:
JET app sample_package 1.0.1
------------------------------
node: re1
------------------------------
Active boot device is primary: /dev/vda
List of installed version(s) :

    '-' running version
    '>' next boot version after upgrade/downgrade
    '<' rollback boot version
    '*' deleted JSU version

 >   junos-evo-install-ptx-x86-64-22.4I20221214085042 - [2022-12-14 09:16:48]
```

```
-   junos-evo-install-ptx-x86-64-22.4I20221214083306 - [2022-12-14 08:58:59]
<   junos-evo-install-ptx-x86-64-22.4I20221214072149 - [2022-12-14 08:04:52]
    junos-evo-install-ptx-x86-64-22.4I20221214055215 - [2022-12-14 06:40:38]

External Software:
JET app sample_package 1.0.1
```

Creating a Bundled ISO

SUMMARY

You can use bundled ISOs to combine a Junos OS Evolved image with third-party packages into a single bundle for easy installation.

IN THIS SECTION

Starting in Junos OS Evolved release 23.2R1, you can bundle a Junos OS Evolved image together with custom applications and scripts to create a bundled ISO. Bundled ISO installation follows the standard Junos OS Evolved software upgrade process. Bundled ISOs help simplify the process of installing third-party applications and scripts.

Bundled ISOs are created using a tool in the JET Toolkit for Junos OS Evolved called `Jet-evo-bundle-iso`. For more information on installing the JET Toolkit for Junos OS Evolved and the `Jet-evo-bundle-iso` tool, see "Installing the JET SDK and JET Toolkit for Junos OS Evolved" on page 106.

`Jet-evo-bundle-iso` Tool Configuration

IN THIS SECTION

The `Jet-evo-bundle-iso` tool is used to generate the bundled ISO. You need to specify the directories containing the files to be bundled into the bundled ISO, and set the install path for the bundled ISO. You can control these variables with the follow options from the `Jet-evo-bundle-iso` command:

```
$ Jet-evo-bundle-iso -h
Usage : Jet-evo-bundle-iso  -p <custom-package-path> -i <input-evo-iso> -n <bundle-name> -o
<output-directory>
```

NOTE: You should include all the third-party packages and scripts that you want to install, even if they exist on the system as part of another bundled ISO or standalone application package.

Required Arguments

The following arguments are required:

-p *directory* Path to the directory containing custom package `tgzs`.

-i *path* Path to the standard Junos OS Evolved ISO that will be included in the bundled ISO.

-o *path* Path where the bundled ISO will be created.

Optional Arguments

The following arguments are optional:

-h Displays a help message explaining the `Jet-evo-bundle-iso` fields.

-n *name* Custom name for the bundled ISO. If a name is not specified, then the output ISO name will be the same as the input ISO.

When you run the `Jet-evo-bundle-iso` command with all the required arguments, the bundled ISO gets created at the path specified by the *-o* argument.

Installing a Bundled ISO

After successfully running the `Jet-evo-bundle-iso` command, you can install the bundled ISO using the regular Junos OS Evolved installation process.

NOTE: Before installing a bundled ISO, you must install the private keys and certificates for the custom packages inside the bundled ISO on each RE. For more information on installing signing keys, see "Importing Signing Keys into the System Keystore and IMA Extended Keyring" on page 92.

Before installation, you can validate the bundled ISO with the following command:

- `request system software validate` *`bundled-iso-path`*

Enter the following command to install the bundled ISO:

- `request system software add` *`bundled-iso-path`*

When the installation process finishes, reboot the device:

- `request system reboot`

After the device reboots, the bundled image will become the running version and all applications in the bundled ISO will start.

If any step of the install process fails for any of the third-party packages inside a bundled ISO, then the installation will fail for the entire bundled ISO.

NOTE: If you are upgrading from a bundled ISO to another bundled ISO, existing third-party packages don't get copied over to the upgraded image. If you wish to upgrade to another bundled ISO and keep using the same third-party packages, then the upgraded image must contain all the same custom packages as the existing image.

After successfully installing a bundled ISO, you can use the `show version` command to confirm the installation. The `[Custom Bundle]` tag next to the currently running version of Junos OS Evolved indicates a bundled ISO installation:

```
user@host> show version
Hostname: host
Model: ptx10008
Junos: 23.2I20230225124619-EVO
Yocto: 3.0.2
Linux Kernel: 5.2.60-yocto-standard-g12117a8
JUNOS-EVO OS 64-bit [junos-evo-install-ptx-x86-64-23.2I20230225131046] [Custom Bundle]
External Software:
JET app custom_logger1.0.1
```

```
JET app multi_app1.1.1
JET app custom_multi_app1.0.1
```

The output of the `show software list` command will also display the `[Custom Bundle]` tag to indicate a bundled ISO:

```
user@host> show system software list
------------------------------
node: re0
------------------------------
Active boot device is primary: /dev/vda
List of installed version(s) :

    '-' running version
    '>' next boot version after upgrade/downgrade
    '<' rollback boot version
    '*' deleted JSU version

-   junos-evo-install-ptx-x86-64-23.2I20230225131046 - [2023-02-25 14:08:17] [Custom Bundle]
       JET app custom_logger 1.0.1
       JET app custom_multi_app 1.0.1
       JET app multi_app 1.1.1
<   junos-evo-install-ptx-x86-64-23.2I20230225124619-EVO - [2023-02-25 13:06:14]
```

NOTE: Third-party packages that have been installed through a bundled ISO can be removed with the same process as independently installed third-party packages. See "Removing Third-Party Applications" on page 104.

Upgrading with a Bundled ISO

You can upgrade from a standard or bundled ISO to another standard or bundled ISO if the Junos OS Evolved image version is the same for both the source and target images. Use the `request system software add restart` *`target-iso`* command to initiate the upgrade process.

For more information on the expected behavior for different bundled ISO upgrade scenarios, see the following list:

Upgrade from standard ISO to bundled ISO	Only the third-party packages from the bundled ISO will be installed.

Upgrade from bundled ISO to standard ISO	All third-party packages from the current bundled ISO will be deleted.
Upgrade from a bundled ISO to a different bundled ISO	All the third-party packages from the current bundled ISO will be deleted and the third-party packages from the incoming bundled ISO will be installed.

NOTE: When you install a standalone third-party package on top of a bundled ISO, it will be considered part of the custom bundle and will not be carried over during upgrades.

Rollback from a Bundled ISO

After installing a bundled ISO, you can rollback to the previous installation by using the `request system software rollback` command. Third-party packages don't get copied when rolling back to a previous release.

4

CHAPTER

Finding Software Documentation for Junos OS Evolved

IN THIS CHAPTER

Where to Find Software Documentation for Junos OS Evolved

SUMMARY

Learn where to find software documentation for Junos OS Evolved in the Juniper Networks TechLibrary.

Looking for Junos OS Evolved documentation? You've come to the correct place! Learn where to find software documentation for Junos OS Evolved in the Junos OS documentation set.

In general, Juniper features and technologies work the same on Junos OS and Junos OS Evolved, so much of the documentation applies to both operating systems. Given the incredible number of features and amount of documentation available, we want to help you and other Junos OS Evolved users find the most relevant content quickly.

In a few cases, Junos OS and Junos OS Evolved differ. Where possible, we inserted inline notes into the documentation like this to highlight the difference or differences.

The following resources specific to Junos OS Evolved will help you get up and running quickly:

- Feature Explorer—Use Feature Explorer to view and compare the software features supported on Junos OS Evolved according to your software release and platform.
- Release Notes—Check out the Release Notes page to obtain the Release Notes for your version of Junos OS Evolved. Learn about new features, known issues, and more!
- Software Guides—Use these OS-specific guides to help you learn about the basics of Junos OS Evolved:
  - CLI User Guide for Junos OS Evolved
  - Getting Started with Junos OS Evolved
  - Interfaces Fundamentals for Junos OS Evolved
  - Introducing Junos OS Evolved
  - Junos OS Evolved Software Installation and Upgrade Guide

- User Access and Authentication Administration Guide for Junos OS Evolved

5

CHAPTER

Configuration Statements and Operational Commands

IN THIS CHAPTER

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