



JUNOS® Software

Software Installation and Upgrade Guide

Release 9.4

Juniper Networks, Inc.

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Part 1

Introduction to JUNOS Software

Chapter 1

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Part 2

JUNOS Software Installation

Chapter 2

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About This Guide

This preface provides the following guidelines for using the *JUNOS® Software Software Installation and Upgrade Guide*:

- Objectives on page xvii
- Audience on page xvii
- Supported Routing Platforms on page xviii
- Documentation Conventions on page xviii
- List of Technical Publications on page xx
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Objectives

This guide provides a description of the JUNOS software packages and includes detailed information about how to initially configure, reinstall, and upgrade the JUNOS system software.



NOTE: This guide documents Release 9.4 of the JUNOS software. For additional information about the JUNOS software—either corrections to or information that might have been omitted from this guide—see the software release notes at <http://www.juniper.net/>.

Audience

This guide is designed for network administrators who are configuring and monitoring a Juniper Networks M-series, MX-series, T-series, EX-series, or J-series router or switch.

To use this guide, you need a broad understanding of networks in general, the Internet in particular, networking principles, and network configuration. You must also be familiar with one or more of the following Internet routing protocols:

- Border Gateway Protocol (BGP)
- Distance Vector Multicast Routing Protocol (DVMRP)
- Intermediate System-to-Intermediate System (IS-IS)
- Internet Control Message Protocol (ICMP) router discovery

- Internet Group Management Protocol (IGMP)
- Multiprotocol Label Switching (MPLS)
- Open Shortest Path First (OSPF)
- Protocol-Independent Multicast (PIM)
- Resource Reservation Protocol (RSVP)
- Routing Information Protocol (RIP)
- Simple Network Management Protocol (SNMP)

Personnel operating the equipment must be trained and competent; must not conduct themselves in a careless, willfully negligent, or hostile manner; and must abide by the instructions provided by the documentation.

Supported Routing Platforms

For the features described in this manual, the JUNOS software currently supports the following routing platforms:

- J-series
- M-series
- MX-series
- T-series

Documentation Conventions

Table 1 on page xviii defines notice icons used in this guide.

Table 1: Notice Icons





| Icon | Meaning | Description |
|---|--------------------|---|
|  | Informational note | Indicates important features or instructions. |
|  | Caution | Indicates a situation that might result in loss of data or hardware damage. |
|  | Warning | Alerts you to the risk of personal injury or death. |
|  | Laser warning | Alerts you to the risk of personal injury from a laser. |

Table 2 on page xix defines the text and syntax conventions used in this guide.

Table 2: Text and Syntax Conventions

| Convention | Description | Examples |
|--------------------------------|---|--|
| Bold text like this | Represents text that you type. | To enter configuration mode, type the configure command: user@host> configure |
| Fixed-width text like this | Represents output that appears on the terminal screen. | user@host> show chassis alarms No alarms currently active |
| <i>Italic text like this</i> | <ul style="list-style-type: none"> Introduces important new terms. Identifies book names. Identifies RFC and Internet draft titles. | <ul style="list-style-type: none"> A policy <i>term</i> is a named structure that defines match conditions and actions. <i>JUNOS System Basics Configuration Guide</i> RFC 1997, <i>BGP Communities Attribute</i> |
| <i>Italic text like this</i> | Represents variables (options for which you substitute a value) in commands or configuration statements. | Configure the machine's domain name: [edit] root@# set system domain-name domain-name |
| Plain text like this | Represents names of configuration statements, commands, files, and directories; IP addresses; configuration hierarchy levels; or labels on routing platform components. | <ul style="list-style-type: none"> To configure a stub area, include the stub statement at the [edit protocols ospf area area-id] hierarchy level. The console port is labeled CONSOLE. |
| < > (angle brackets) | Enclose optional keywords or variables. | stub <default-metric <i>metric</i> >; |
| (pipe symbol) | Indicates a choice between the mutually exclusive keywords or variables on either side of the symbol. The set of choices is often enclosed in parentheses for clarity. | broadcast multicast (string1 string2 string3) |
| # (pound sign) | Indicates a comment specified on the same line as the configuration statement to which it applies. | rsvp { # Required for dynamic MPLS only |
| [] (square brackets) | Enclose a variable for which you can substitute one or more values. | community name members [<i>community-ids</i>] |
| Indentation and braces ({ }) | Identify a level in the configuration hierarchy. | [edit] routing-options { static { route default { nexthop address; retain; } } } |
| ; (semicolon) | Identifies a leaf statement at a configuration hierarchy level. | |

Table 2: Text and Syntax Conventions (*continued*)

| Convention | Description | Examples |
|------------------------------|--|---|
| J-Web GUI Conventions | | |
| Bold text like this | Represents J-Web graphical user interface (GUI) items you click or select. | <ul style="list-style-type: none"> ■ In the Logical Interfaces box, select All Interfaces. ■ To cancel the configuration, click Cancel. |
| > (bold right angle bracket) | Separates levels in a hierarchy of J-Web selections. | In the configuration editor hierarchy, select Protocols > Ospf . |

List of Technical Publications

Table 3 on page xx lists the software and hardware guides and release notes for Juniper Networks M-series, MX-series, and T-series routing platforms and describes the contents of each document. Table 4 on page xxiv lists the books included in the *Network Operations Guide* series. Table 5 on page xxv lists the manuals and release notes supporting JUNOS software for J-series and SRX-series platforms. All documents are available at <http://www.juniper.net/techpubs/>.

Table 6 on page xxvi lists additional books on Juniper Networks solutions that you can order through your bookstore. A complete list of such books is available at <http://www.juniper.net/books>.

Table 3: Technical Documentation for Supported Routing Platforms

| Book | Description |
|---|---|
| JUNOS Software for Supported Routing Platforms | |
| <i>Access Privilege</i> | Explains how to configure access privileges in user classes by using permission flags and regular expressions. Lists the permission flags along with their associated command-line interface (CLI) operational mode commands and configuration statements. |
| <i>Broadband Subscriber Management Solutions</i> | Describes residential subscriber management and how you can deploy solutions that include multisubscriber IP address assignment, service provisioning, authentication, authorization, accounting, and dynamic request services in your network |
| <i>Class of Service</i> | Provides an overview of the class-of-service (CoS) functions of the JUNOS software and describes how to configure CoS features, including configuring multiple forwarding classes for transmitting packets, defining which packets are placed into each output queue, scheduling the transmission service level for each queue, and managing congestion through the random early detection (RED) algorithm. |
| <i>CLI User Guide</i> | Describes how to use the JUNOS command-line interface (CLI) to configure, monitor, and manage Juniper Networks routing platforms. This material was formerly covered in the <i>JUNOS System Basics Configuration Guide</i> . |

Table 3: Technical Documentation for Supported Routing Platforms (*continued*)

| Book | Description |
|--|--|
| <i>Feature Guide</i> | Provides a detailed explanation and configuration examples for several of the most complex features in the JUNOS software. |
| <i>High Availability</i> | Provides an overview of hardware and software resources that ensure a high level of continuous routing platform operation and describes how to configure high availability (HA) features such as nonstop active routing (NSR) and graceful Routing Engine switchover (GRES). |
| <i>MPLS Applications</i> | Provides an overview of traffic engineering concepts and describes how to configure traffic engineering protocols. |
| <i>Multicast Protocols</i> | Provides an overview of multicast concepts and describes how to configure multicast routing protocols. |
| <i>Multiplay Solutions</i> | Describes how you can deploy IPTV and voice over IP (VoIP) services in your network. |
| <i>MX-series Layer 2 Configuration Guide</i> | Provides an overview of the Layer 2 functions of the MX-series routers, including configuring bridging domains, MAC address and VLAN learning and forwarding, and spanning-tree protocols. It also details the routing instance types used by Layer 2 applications. All of this material was formerly covered in the <i>JUNOS Routing Protocols Configuration Guide</i> . |
| <i>MX-series Layer 2 Solutions Guide</i> | Describes common configuration scenarios for the Layer 2 features supported on the MX-series routers, including basic bridged VLANs with normalized VLAN tags, aggregated Ethernet links, bridge domains, Multiple Spanning Tree Protocol (MSTP), and integrated routing and bridging (IRB). |
| <i>Network Interfaces</i> | Provides an overview of the network interface functions of the JUNOS software and describes how to configure the network interfaces on the routing platform. |
| <i>Network Management</i> | Provides an overview of network management concepts and describes how to configure various network management features, such as SNMP and accounting options. |
| <i>Policy Framework</i> | Provides an overview of policy concepts and describes how to configure routing policy, firewall filters, and forwarding options. |
| <i>Protected System Domain</i> | Provides an overview of the JCS 1200 platform and the concept of Protected System Domains (PSDs). The JCS 1200 platform, which contains up to six redundant pairs of Routing Engines running JUNOS software, is connected to a T320 router or to a T640 or T1600 routing node. To configure a PSD, you assign any number of Flexible PIC concentrators (FPCs) in the T-series routing platform to a pair of Routing Engines on the JCS 1200 platform. Each PSD has the same capabilities and functionality as a physical router, with its own control plane, forwarding plane, and administration. |
| <i>Routing Protocols</i> | Provides an overview of routing concepts and describes how to configure routing instances, and unicast routing protocols. |

Table 3: Technical Documentation for Supported Routing Platforms (*continued*)

| Book | Description |
|--|---|
| <i>Secure Configuration Guide for Common Criteria and JUNOS-FIPS</i> | Provides an overview of secure Common Criteria and JUNOS-FIPS protocols for the JUNOS software and describes how to install and configure secure Common Criteria and JUNOS-FIPS on a routing platform. |
| <i>Services Interfaces</i> | Provides an overview of the services interfaces functions of the JUNOS software and describes how to configure the services interfaces on the router. |
| <i>Software Installation and Upgrade Guide</i> | Describes the JUNOS software components and packaging and explains how to initially configure, reinstall, and upgrade the JUNOS system software. This material was formerly covered in the <i>JUNOS System Basics Configuration Guide</i> . |
| <i>Subscriber Access</i> | Provides an overview of the subscriber access features of the JUNOS software and describes how to configure subscriber access support on the router, including dynamic profiles, class of service, AAA, and access methods. |
| <i>System Basics</i> | Describes Juniper Networks routing platforms and explains how to configure basic system parameters, supported protocols and software processes, authentication, and a variety of utilities for managing your router on the network. |
| <i>VPNs</i> | Provides an overview and describes how to configure Layer 2 and Layer 3 virtual private networks (VPNs), virtual private LAN service (VPLS), and Layer 2 circuits. Provides configuration examples. |
| JUNOS References | |
| <i>Hierarchy and RFC Reference</i> | Describes the JUNOS configuration mode commands. Provides a hierarchy reference that displays each level of a configuration hierarchy, and includes all possible configuration statements that can be used at that level. This material was formerly covered in the <i>JUNOS System Basics Configuration Guide</i> . |
| <i>Interfaces Command Reference</i> | Describes the JUNOS software operational mode commands you use to monitor and troubleshoot interfaces. |
| <i>Routing Protocols and Policies Command Reference</i> | Describes the JUNOS software operational mode commands you use to monitor and troubleshoot routing policies and protocols, including firewall filters. |
| <i>System Basics and Services Command Reference</i> | Describes the JUNOS software operational mode commands you use to monitor and troubleshoot system basics, including commands for real-time monitoring and route (or path) tracing, system software management, and chassis management. Also describes commands for monitoring and troubleshooting services such as class of service (CoS), IP Security (IPsec), stateful firewalls, flow collection, and flow monitoring. |
| <i>System Log Messages Reference</i> | Describes how to access and interpret system log messages generated by JUNOS software modules and provides a reference page for each message. |
| J-Web User Guide | |

Table 3: Technical Documentation for Supported Routing Platforms *(continued)*

| Book | Description |
|--|---|
| <i>J-Web Interface User Guide</i> | Describes how to use the J-Web graphical user interface (GUI) to configure, monitor, and manage Juniper Networks routing platforms. |
| JUNOS API and Scripting Documentation | |
| <i>JUNOScript API Guide</i> | Describes how to use the JUNOScript application programming interface (API) to monitor and configure Juniper Networks routing platforms. |
| <i>JUNOS XML API Configuration Reference</i> | Provides reference pages for the configuration tag elements in the JUNOS XML API. |
| <i>JUNOS XML API Operational Reference</i> | Provides reference pages for the operational tag elements in the JUNOS XML API. |
| <i>NETCONF API Guide</i> | Describes how to use the NETCONF API to monitor and configure Juniper Networks routing platforms. |
| <i>JUNOS Configuration and Diagnostic Automation Guide</i> | Describes how to use the commit script and self-diagnosis features of the JUNOS software. This guide explains how to enforce custom configuration rules defined in scripts, how to use commit script macros to provide simplified aliases for frequently used configuration statements, and how to configure diagnostic event policies. |
| Hardware Documentation | |
| <i>Hardware Guide</i> | Describes how to install, maintain, and troubleshoot routing platforms and components. Each platform has its own hardware guide. |
| <i>PIC Guide</i> | Describes the routing platform's Physical Interface Cards (PICs). Each platform has its own PIC guide. |
| <i>DPC Guide</i> | Describes the Dense Port Concentrators (DPCs) for all MX-series routers. |
| JUNOScope Documentation | |
| <i>JUNOScope Software User Guide</i> | Describes the JUNOScope software graphical user interface (GUI), how to install and administer the software, and how to use the software to manage routing platform configuration files and monitor routing platform operations. |
| Advanced Insight Solutions (AIS) Documentation | |
| <i>Advanced Insight Solutions Guide</i> | Describes the Advanced Insight Manager (AIM) application, which provides a gateway between JUNOS devices and Juniper Support Systems (JSS) for case management and intelligence updates. Explains how to run AI-Scripts on Juniper Networks devices. |
| Release Notes | |

Table 3: Technical Documentation for Supported Routing Platforms (*continued*)

| Book | Description |
|-------------------------------------|---|
| <i>JUNOS Release Notes</i> | Summarize new features and known problems for a particular software release, provide corrections and updates to published JUNOS, JUNOScript, and NETCONF manuals, provide information that might have been omitted from the manuals, and describe upgrade and downgrade procedures. |
| <i>Hardware Release Notes</i> | Describe the available documentation for the routing platform and summarize known problems with the hardware and accompanying software. Each platform has its own release notes. |
| <i>JUNOScope Release Notes</i> | Contain corrections and updates to the published JUNOScope manual, provide information that might have been omitted from the manual, and describe upgrade and downgrade procedures. |
| <i>AIS Release Notes</i> | Summarize AIS new features and guidelines, identify known and resolved problems, provide information that might have been omitted from the manuals, and provide initial setup, upgrade, and downgrade procedures. |
| <i>AIS AI-Scripts Release Notes</i> | Summarize AI-Scripts new features, identify known and resolved problems, provide information that might have been omitted from the manuals, and provide instructions for automatic and manual installation, including deleting and rolling back. |

Table 4: JUNOS Software Network Operations Guides

| Book | Description |
|---------------------------|--|
| <i>Baseline</i> | Describes the most basic tasks for running a network using Juniper Networks products. Tasks include upgrading and reinstalling JUNOS software, gathering basic system management information, verifying your network topology, and searching log messages. |
| <i>Interfaces</i> | Describes tasks for monitoring interfaces. Tasks include using loopback testing and locating alarms. |
| <i>MPLS</i> | Describes tasks for configuring, monitoring, and troubleshooting an example MPLS network. Tasks include verifying the correct configuration of the MPLS and RSVP protocols, displaying the status and statistics of MPLS running on all routing platforms in the network, and using the layered MPLS troubleshooting model to investigate problems with an MPLS network. |
| <i>MPLS Log Reference</i> | Describes MPLS status and error messages that appear in the output of the <code>show mpls lsp extensive</code> command. The guide also describes how and when to configure Constrained Shortest Path First (CSPF) and RSVP trace options, and how to examine a CSPF or RSVP failure in a sample network. |
| <i>MPLS Fast Reroute</i> | Describes operational information helpful in monitoring and troubleshooting an MPLS network configured with fast reroute (FRR) and load balancing. |

Table 4: JUNOS Software Network Operations Guides (*continued*)

| Book | Description |
|-----------------|---|
| <i>Hardware</i> | Describes tasks for monitoring M-series and T-series routing platforms. |

To configure and operate a J-series Services Router or an SRX-series Services Gateway running JUNOS software, you must also use the configuration statements and operational mode commands documented in JUNOS configuration guides and command references. To configure and operate a WX Integrated Services Module, you must also use WX documentation.

Table 5: JUNOS Software for J-series Services Routers and SRX-series Services Gateways Documentation

| Book | Description |
|--|---|
| J-series and SRX-series Platforms | |
| <i>JUNOS Software Interfaces and Routing Configuration Guide</i> | Explains how to configure SRX-series and J-series interfaces for basic IP routing with standard routing protocols, ISDN service, firewall filters (access control lists), and class-of-service (CoS) traffic classification. |
| <i>JUNOS Software Security Configuration Guide</i> | Explains how to configure and manage SRX-series and J-series security services such as stateful firewall policies, IPsec VPNs, firewall screens, Network Address Translation (NAT), Public Key Cryptography, chassis clusters, Application Layer Gateways (ALGs), and Intrusion Detection and Prevention (IDP). |
| <i>JUNOS Software Administration Guide</i> | Shows how to monitor SRX-series and J-series devices and routing operations, firewall and security services, system alarms and events, and network performance. This guide also shows how to administer user authentication and access, upgrade software, and diagnose common problems. |
| <i>JUNOS Software CLI Reference</i> | Provides the complete configuration hierarchy available on SRX-series and J-series devices. This guide also describes the configuration statements and operational mode commands unique to these devices. |
| <i>JUNOS Release Notes</i> | Summarize new features and known problems for a particular release of JUNOS software, including JUNOS software for J-series and SRX-series devices. The release notes also contain corrections and updates to the manuals and software upgrade and downgrade instructions for JUNOS software. |
| J-series Only | |
| <i>JUNOS Software Design and Implementation Guide</i> | Provides guidelines and examples for designing and implementing IPsec VPNs, firewalls, and routing on J-series Services Routers running JUNOS software. |

Table 5: JUNOS Software for J-series Services Routers and SRX-series Services Gateways Documentation (continued)

| Book | Description |
|--|---|
| <i>J-series Services Routers Quick Start</i> | Explains how to quickly set up a J-series Services Router. This document contains router declarations of conformity. |
| <i>J-series Services Routers Hardware Guide</i> | Provides an overview, basic instructions, and specifications for J-series Services Routers. This guide explains how to prepare a site, unpack and install the router, replace router hardware, and establish basic router connectivity. This guide contains hardware descriptions and specifications. |
| <i>JUNOS Software Migration Guide</i> | Provides instructions for migrating an SSG device running ScreenOS software to JUNOS software or upgrading a J-series device to a later version of the JUNOS software. |
| <i>WXC Integrated Services Module Installation and Configuration Guide</i> | Explains how to install and initially configure a WXC Integrated Services Module in a J-series Services Router for application acceleration. |

Table 6: Additional Books Available Through <http://www.juniper.net/books>

| Book | Description |
|---|--|
| <i>Interdomain Multicast Routing</i> | Provides background and in-depth analysis of multicast routing using Protocol Independent Multicast sparse mode (PIM SM) and Multicast Source Discovery Protocol (MSDP); details any-source and source-specific multicast delivery models; explores multiprotocol BGP (MBGP) and multicast IS-IS; explains Internet Gateway Management Protocol (IGMP) versions 1, 2, and 3; lists packet formats for IGMP, PIM, and MSDP; and provides a complete glossary of multicast terms. |
| <i>JUNOS Cookbook</i> | Provides detailed examples of common JUNOS software configuration tasks, such as basic router configuration and file management, security and access control, logging, routing policy, firewalls, routing protocols, MPLS, and VPNs. |
| <i>MPLS-Enabled Applications</i> | Provides an overview of Multiprotocol Label Switching (MPLS) applications (such as Layer 3 virtual private networks [VPNs], Layer 2 VPNs, virtual private LAN service [VPLS], and pseudowires), explains how to apply MPLS, examines the scaling requirements of equipment at different points in the network, and covers the following topics: point-to-multipoint label switched paths (LSPs), DiffServ-aware traffic engineering, class of service, interdomain traffic engineering, path computation, route target filtering, multicast support for Layer 3 VPNs, and management and troubleshooting of MPLS networks. |
| <i>OSPF and IS-IS: Choosing an IGP for Large-Scale Networks</i> | Explores the full range of characteristics and capabilities for the two major link-state routing protocols: Open Shortest Path First (OSPF) and IS-IS. Explains architecture, packet types, and addressing; demonstrates how to improve scalability; shows how to design large-scale networks for maximum security and reliability; details protocol extensions for MPLS-based traffic engineering, IPv6, and multipoint-to-multipoint routing; and covers troubleshooting for OSPF and IS-IS networks. |
| <i>Routing Policy and Protocols for Multivendor IP Networks</i> | Provides a brief history of the Internet, explains IP addressing and routing (Routing Information Protocol [RIP], OSPF, IS-IS, and Border Gateway Protocol [BGP]), explores ISP peering and routing policies, and displays configurations for both Juniper Networks and other vendors' routers. |

Table 6: Additional Books Available Through <http://www.juniper.net/books> (continued)

| Book | Description |
|------------------------------------|---|
| <i>The Complete IS-IS Protocol</i> | Provides the insight and practical solutions necessary to understand the IS-IS protocol and how it works by using a multivendor, real-world approach. |

Documentation Feedback

We encourage you to provide feedback, comments, and suggestions so that we can improve the documentation. You can send your comments to techpubs-comments@juniper.net, or fill out the documentation feedback form at <https://www.juniper.net/cgi-bin/docbugreport/>. If you are using e-mail, be sure to include the following information with your comments:

- Document name
- Document part number
- Page number
- Software release version (not required for *Network Operations Guides [NOGs]*)

Requesting Technical Support

Technical product support is available through the Juniper Networks Technical Assistance Center (JTAC). If you are a customer with an active J-Care or JNASC support contract, or are covered under warranty, and need postsales technical support, you can access our tools and resources online or open a case with JTAC.

- JTAC policies—For a complete understanding of our JTAC procedures and policies, review the JTAC User Guide located at <http://www.juniper.net/customers/support/downloads/710059.pdf>.
- Product warranties—For product warranty information, visit <http://www.juniper.net/support/warranty/>.
- JTAC Hours of Operation —The JTAC centers have resources available 24 hours a day, 7 days a week, 365 days a year.

Self-Help Online Tools and Resources

For quick and easy problem resolution, Juniper Networks has designed an online self-service portal called the Customer Support Center (CSC) that provides you with the following features:

- Find CSC offerings: <http://www.juniper.net/customers/support/>
- Search for known bugs: <http://www2.juniper.net/kb/>
- Find product documentation: <http://www.juniper.net/techpubs/>
- Find solutions and answer questions using our Knowledge Base: <http://kb.juniper.net/>

- Download the latest versions of software and review release notes:
<http://www.juniper.net/customers/csc/software/>
- Search technical bulletins for relevant hardware and software notifications:
<https://www.juniper.net/alerts/>
- Join and participate in the Juniper Networks Community Forum:
<http://www.juniper.net/company/communities/>
- Open a case online in the CSC Case Management tool: <http://www.juniper.net/cm/>

To verify service entitlement by product serial number, use our Serial Number Entitlement (SNE) Tool located at <https://tools.juniper.net/SerialNumberEntitlementSearch/>.

Opening a Case with JTAC

You can open a case with JTAC on the Web or by telephone.

- Use the Case Management tool in the CSC at <http://www.juniper.net/cm/> .
- Call 1-888-314-JTAC (1-888-314-5822 toll-free in the USA, Canada, and Mexico).

For international or direct-dial options in countries without toll-free numbers, visit us at <http://www.juniper.net/support/requesting-support.html>.

Part 1

Introduction to JUNOS Software

- Introduction on page 3

Chapter 1

Introduction

This chapter includes the following sections:

- Introduction to JUNOS on page 3
- Hardware Architecture on page 4
- Software Overview on page 12

Introduction to JUNOS

Juniper Networks provides high-performance network devices that create a responsive and trusted environment for accelerating the deployment of services and applications over a single network. JUNOS software is the foundation of these high-performance networks. Unlike other complex, monolithic software architectures, JUNOS software incorporates key design and developmental differences to deliver increased network availability, operational efficiency, and flexibility. The key advantages to this approach are:

- One Operating System on page 3
- One Software Release on page 3
- One Modular Software Architecture on page 4

One Operating System

Unlike other network operating systems that share a common name but splinter into many different programs, JUNOS software is a single, cohesive operating system that is shared across all routers and product lines. This allows Juniper Networks engineers to develop software features once and share these features across all product lines simultaneously. Because features are common to a single source, they generally are implemented the same way for all product lines, thus reducing the training required to learn different tools and methods for each product. Because all Juniper Networks products use the same code base, interoperability between products is not an issue.

One Software Release

Each new version of JUNOS software is released concurrently for all product lines following a preset quarterly schedule. Furthermore, each new version of software must include all working features released in previous releases of the software, and must have no critical regression errors. This discipline ensures reliable operations for the entire release.

One Modular Software Architecture

Although individual modules of the JUNOS software communicate through well-defined interfaces, each module runs in its own protected memory space, preventing one module from disrupting another. This separation enables the independent restart of each module as necessary. This is in contrast to monolithic operating systems where a malfunction in one module can ripple to other modules and cause a full system crash or restart. This modular architecture then provides for high performance, high availability, security, and device scalability not found in other operating systems.

The JUNOS software is preinstalled on your Juniper Networks router when you receive it from the factory. Thus, when you first power on the router, all software starts automatically. You simply need to configure the software so that the router can participate in the network.

You can upgrade the router software as new features are added or software problems are fixed. You normally obtain new software by downloading the software installation packages from the Juniper Networks Support Web page onto your router or onto another system on your local network. You then install the software upgrade onto the router.

Juniper Networks routing platforms run only binaries supplied by Juniper Networks. Each JUNOS software image includes a digitally signed manifest of executables that are registered with the system only if the signature can be validated. JUNOS software will not execute any binary without a registered signature. This feature protects the system against unauthorized software and activity that might compromise the integrity of your router.

Related Topics *Impacts of the Operating System on the Performance of Enterprise Networks white paper:*
http://www.juniper.net/solutions/literature/white_papers/200239.pdf

Hardware Architecture

The hardware architecture is detailed in the following sections:

- Hardware Architecture Overview on page 4
- M-series, MX-series, T-series, and TX Matrix Routing Platforms on page 5
- J-series Routers on page 10

Hardware Architecture Overview

Juniper Network routing platforms are made up of two basic routing components:

- Routing Engine—The Routing Engine controls the routing updates and system management.
- Packet Forwarding Engine (PFE)—The Packet Forwarding Engine performs Layer 2 and Layer 3 packet switching, route lookups, and packet forwarding.

From a system administration perspective, you install the software onto the Routing Engine and during the installation, the appropriate software is forwarded to other components as necessary. Each Routing Engine includes a CompactFlash card that

stores the JUNOS software. On the M-series, MX-series, T-series, and TX Matrix platforms, the system also includes a hard drive that acts as a backup boot drive.

On routing platforms with dual Routing Engines, each Routing Engine is independent with regard to upgrading the software. To install new software on both Routing Engines, you need to install the new software on each Routing Engine. On platforms with dual Routing Engines configured for high availability, you can use the unified in-service software upgrade procedure to upgrade the software. For more information on this procedure, see the *JUNOS High Availability Configuration Guide*.

M-series, MX-series, T-series, and TX Matrix Routing Platforms

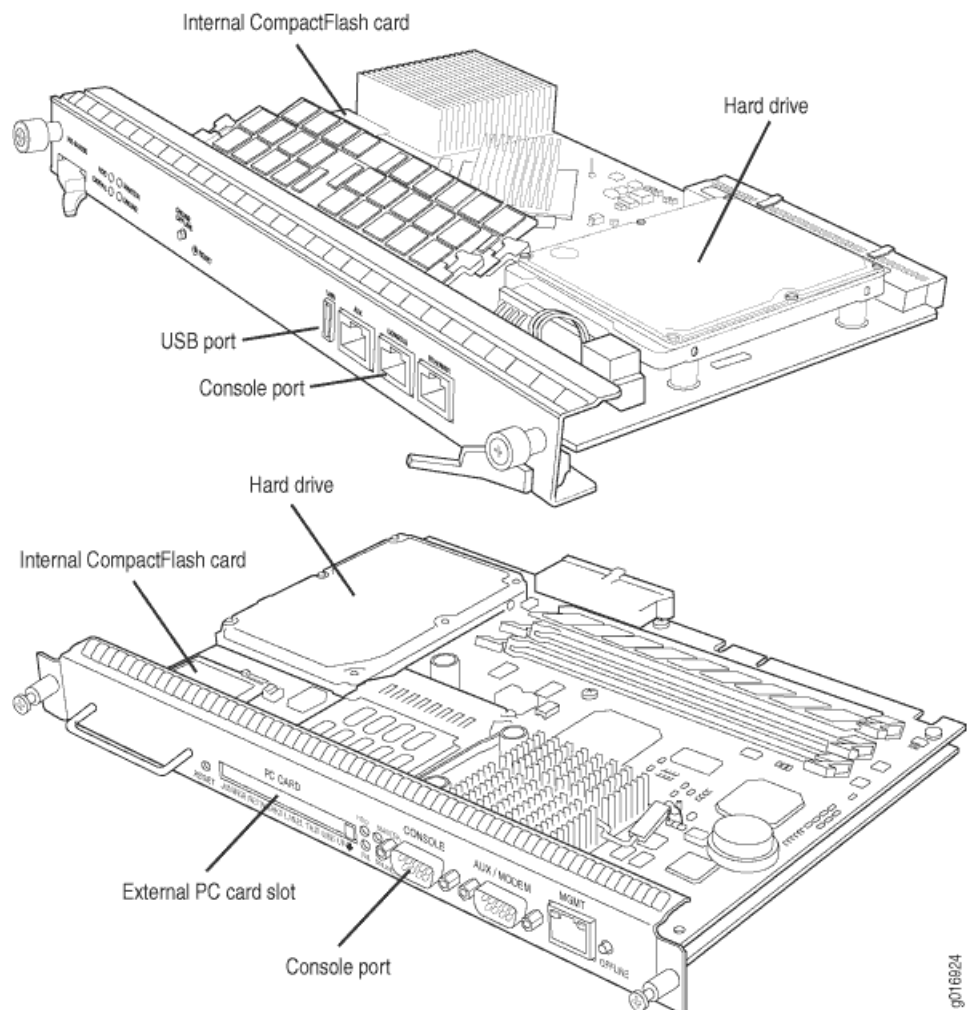
The following topics give a brief overview of the M-series, MX-series, T-series, and the TX Matrix routing platforms.

- M-series, MX-series, T-series, and TX Matrix Routing Platforms Hardware Overview on page 6
- Routing Engines and Storage Media Names on page 8
- M-series, MX-series, T-series, and TX Matrix Routing Platforms Boot Sequence on page 9

M-series, MX-series, T-series, and TX Matrix Routing Platforms Hardware Overview

The JUNOS software is installed on both the CompactFlash card and the hard drive. When installed, the internal CompactFlash card is the primary boot device and the hard drive is the secondary boot device. When the internal CompactFlash card is not installed, the hard drive is the primary boot device. Depending on the Routing Engine installed on your system, you are also supplied with an external boot device: a CompactFlash card, a USB device, or an LS-120 disk drive. These external devices are emergency boot devices and can be used to revive a routing platform with damaged JUNOS software. When these external devices are attached to the system, the router attempts to boot from these devices before it boots from the internal CompactFlash drive or the hard drive. Figure 1 on page 7 shows the standard layout of a typical Routing Engine.

Figure 1: Routing Engines



When booting from the external emergency boot disk, the router requests a boot acknowledgment from you on the console interface. If you enter yes, the external media repartitions the internal primary drive and reloads the JUNOS software onto that drive. When the loading is complete, the routing platform requests that you remove the external media and reboot the system. Once the reboot is complete, you

must perform an initial configuration of the router before it can be used on your network.

The M-series, MX-series, T-series and TX Matrix routing platforms include the following:

- System Memory on page 8
- Storage Media on page 8

System Memory

Starting with JUNOS Release 9.0, all routing platforms require a minimum of 512 MB of system memory on each Routing Engine. All M7i and M10i routers delivered before December 7, 2007, were installed with 256 MB of memory. These routers require a system memory upgrade before you install JUNOS Release 9.0. To determine the amount of memory currently installed on your system, use the **show chassis routing-engine** command in the command-line interface (CLI).

For more information on upgrading your M7i or M10i router, see the Customer Support Center JTAC Technical Bulletin PSN-2007-10-001:
<https://www.juniper.net/alerts/viewalert.jsp?txtAlertNumber=PSN-2007-10-001&actionBtn=Search>.

Storage Media

The M-series, MX-series, T-series, and TX Matrix routing platforms use the following media storage devices:

- CompactFlash card—The CompactFlash card is typically the primary storage device. From the factory, M7i and M10i routers are not usually delivered with the CompactFlash card installed. In this case, the hard drive is the primary and only boot device. The M7i and M10i routers can be upgraded to include the CompactFlash card.
- Hard drive—The hard drive is normally the secondary boot device. When the CompactFlash card is not installed on the router, the hard drive becomes the primary boot drive. The hard drive is also used to store system log files and diagnostic dump files.
- External media storage device—Depending on the system, the external device can be a CompactFlash card, a USB storage device, or an LS-120 floppy disk.

Routing Engines and Storage Media Names

Table 7 on page 9 specifies the storage media names by Routing Engine. The storage media device names are displayed when the router boots.

Table 7: Routing Engines and Storage Media Names

| Routing Engine | CompactFlash Card | Hard Disk | Removable Media |
|--|-------------------|-----------|-----------------|
| RE-400-768 (RE5) Supported platforms: M7i and M10i | ad0 | ad1 | ad3 |
| RE-600-2048 (RE3) Supported platforms: M20 and M40e | ad0 | ad1 | ad3 |
| RE-850-1536 (RE-850) Supported platforms: M7i and M10i | ad0 | ad1 | ad3 |
| RE-A-1000-2048 (RE-A-1000) Supported platforms: M120 | ad0 | ad2 | da0 |
| RE-S-1300-2048 (RE-S-1300) Supported platforms: MX240, MX480, and MX960 | ad0 | ad2 | da0 |
| RE-1600-2048 (RE4) Supported platforms: M320, T320, T640, T1600, and the TX Matrix | ad0 | ad1 | ad3 and ad4 |
| RE-A-2000-4096 (RE-A-2000) Supported platforms: M120, M320, MX240, MX480, MX960, T320, T640, T1600, and the TX Matrix | ad0 | ad2 | da0 |

To view the storage media currently available on your system, use the CLI **show system storage** command. For more information about this command, see the *JUNOS CLI User's Guide*.

M-series, MX-series, T-series, and TX Matrix Routing Platforms Boot Sequence

The router attempts to boot from the storage media in the following order:

1. Removable media
2. CompactFlash card (if available)
3. Hard disk



NOTE: Do not insert the removable media during normal operations. The router does not operate normally when it is booted from the removable media.

If the router boots from an alternate boot device, the JUNOS software displays a message indicating this when you log in to the router. For example, the following message shows that the software booted from the hard disk (*/dev/ad2s1a*):

```
login: username
Password: password
Last login: date on terminal
— JUNOS 8.0 R1 built date
—
— NOTICE: System is running on alternate media device (/dev/ad2s1a).
```

Related Topics The following HTML pages offer more information on the M-series, MX-series, T-series, and TX-series routing platform architecture:

- Router Architecture for M-series Routers and T-series Platforms:
<http://www.juniper.net/techpubs/software/nog/nog-baseline/html/juniper-routers3.html>
- Hardware Components of the M-series and T-series Routing Platforms:
<http://www.juniper.net/techpubs/software/nog/nog-baseline/html/juniper-routers7.html>

J-series Routers

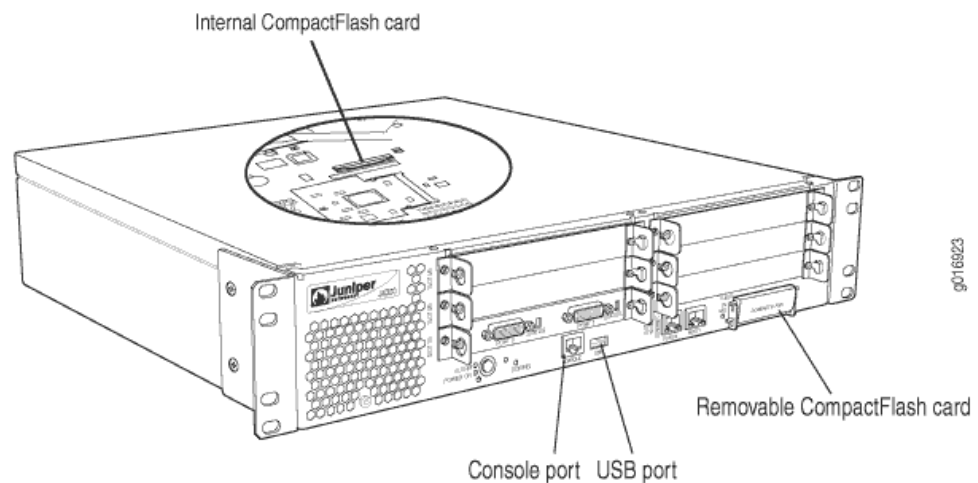
The following topics give a brief overview of the J-series routers.

- J-series Routers Hardware Overview on page 11
- Storage Media Names on page 12
- J-series Routers Boot Sequence on page 12

J-series Routers Hardware Overview

The JUNOS software is installed on the internal CompactFlash card. This internal CompactFlash card is the primary and only boot drive on the J-series routers when they are delivered from the factory. All J-series routers have one or more USB ports. The 4300 and 6300 J-series routers also include an external CompactFlash card slot. You can install external storage devices through the USB ports and CompactFlash card slots. When external storage devices are installed, these external devices can be used as backup boot drives. You can also create a backup internal boot drive on any externally attached CompactFlash card. This CompactFlash card can then be used to replace the internal CompactFlash card on the J-series router in the event that the internal card is damaged or otherwise made unusable by the router. Figure 2 on page 11 shows the location of the memory and ports on a J-series router.

Figure 2: J-series Routers (J4300 Shown)



The J-series routers include the following:

- System Memory on page 11
- Storage Media on page 12

System Memory

Starting with JUNOS Release 9.1, all J-series routing platforms require a minimum of 512 MB of router memory on each Routing Engine. Any router without this minimum requires a system memory upgrade before you install JUNOS Release 9.1. To determine the amount of memory currently installed on your router, use the CLI `show chassis routing-engine` command.

For more information on memory requirements for the J-series routers, see the Customer Support Center JTAC Technical Bulletin PSN-2008-04-021:
<http://www.juniper.net/alerts/viewalert.jsp?txtAlertNumber=PSN-2008-04-021&actionBtn=Search>.

Storage Media

The J-series routers use the following media storage devices:

- Internal CompactFlash card—The CompactFlash card is the primary boot device.
- External media device—Depending on the system, this external device can be a CompactFlash card or a USB storage device. Juniper Networks recommends that you attach an external device to the system and use this external device as the backup boot device for the system.

Storage Media Names

Table 8 on page 12 specifies the storage media names used by the J-series routers. The storage media device names are displayed as the router boots.

Table 8: Routing Engines and Storage Media Names

| Routing Engine | Internal CompactFlash Card | External CompactFlash Card J4300 and J6300 Routers Only | USB Storage Media Devices |
|------------------|----------------------------|---|---------------------------|
| J-series Routers | ad0 | ad2 | da0 |

To view the storage media currently available on your system, use the CLI `show system storage` command. For more information about this command, see the *JUNOS CLI User's Guide*.

J-series Routers Boot Sequence

The router attempts to boot from the storage media in the following order:

1. Internal CompactFlash card
2. External CompactFlash card (J4300 and J6300 routers only)
3. USB storage media device

Software Overview

The software overview is detailed in the following sections:

- Software Naming Convention on page 13
- JUNOS Software Editions on page 13
- FIPS 140-2 Security Compliance on page 13
- JUNOS Software Packages on page 14
- JUNOS Software Release Numbers on page 16
- JUNOS Feature Licenses on page 17

- Software Package Information Security on page 17
- Configuration Files on page 17

Software Naming Convention

All JUNOS software conforms to the following naming convention:

package-release-edition-cfxxx-signed.comp

For example:

jinstall-9.2R1.8-domestic-signed.tgz

where:

- *package* is the name of the JUNOS package.
- *cfxxx* designates the CompactFlash card size to use with the software. This value is optional.
- *signed* means that the software includes a digital signature for verification purposes. This value is not used with all software packages.

JUNOS Software Editions

JUNOS software is released in the following formats:

- Domestic—JUNOS software for customers in the United States and Canada. This edition includes high-encryption capabilities for data leaving the router.
- Export—JUNOS software for all other customers. This edition does not include any high-encryption capabilities for data leaving the router.
- JUNOS-FIPS—JUNOS software that provides advanced network security for customers who need software tools to configure a network of Juniper Networks routers in a Federal Information Processing Standards (FIPS) 140-2 environment. For more information about JUNOS-FIPS, see “FIPS 140-2 Security Compliance” on page 13.

FIPS 140-2 Security Compliance

For advanced network security, a special version of JUNOS, called JUNOS-FIPS 140-2, is available. JUNOS-FIPS 140-2 provides customers with software tools to configure a network of Juniper Networks routers in a FIPS environment. FIPS support includes:

- Upgrade package to convert JUNOS to JUNOS-FIPS 140-2
- Revised installation and configuration procedures
- Enforced security for remote access
- FIPS user roles (Crypto Officer, User, and Maintenance)
- FIPS-specific system logging and error messages

- IPsec configuration for Routing Engine-to-Routing Engine communication
- Enhanced password creation and encryption

JUNOS-FIPS has special installation and configuration requirements. Installation procedures include downloading the FIPS software package from www.juniper.net. For detailed guidelines on how installation and configuration procedures differ between JUNOS and JUNOS-FIPS 140-2, see the *Secure Configuration Guide for Common Criteria and JUNOS-FIPS*.



NOTE: JUNOS-FIPS has special password requirements. FIPS passwords must be between 10 and 20 characters in length. Passwords must use at least three of the five defined character sets (uppercase letters, lowercase letters, digits, punctuation marks, and other special characters). If JUNOS-FIPS is installed on the router, you cannot configure passwords unless they meet this standard.

JUNOS Software Packages

The JUNOS software comes in different *packages*, or collections of files that are installed onto the router:

- JUNOS Installation Packages on page 14
- Installation Media on page 15
- Installation Bundles on page 15
- Installation Modules on page 16

JUNOS Installation Packages

The installation package is used to upgrade and downgrade from one release to another. When installed, the installation package completely reinstalls the software, rebuilds the JUNOS file system, and may erase system logs and other auxiliary information from the previous installation. The installation package does, however, retain the configuration files from the previous installation.

The following installation packages are available for download:

| Installation Package | Description |
|----------------------|---|
| jinstall* | JUNOS software for the M-series, MX-series, T-series, and TX Matrix routing platforms. |
| jinstall-ex* | JUNOS software for the EX-series Ethernet switch portfolio. |
| junos-jsr* | JUNOS software for the J-series routers. |
| junos-juniper* | JUNOS-FIPS for the M-series, MX-series, T-series, and TX Matrix routing platforms. Once the package is installed on a routing platform, you cannot revert back to the standard JUNOS software installation without performing a software recovery procedure. |

Installation Media

The installation media is used to recover a router from a software failure. The installation media repartitions the media and completely reinstalls the JUNOS software. No information from previous installations is retained during this installation. Thus, an initial configuration is required before the router can be put back into service. For more information on creating an initial configuration, see the *Getting Started Guide* for your router.



NOTE: Once you have rebuilt a router using the installation media, access to the router is restricted to the console port until the management port is configured during the initial configuration.

The following installation media files are available for download:

| Installation Media | Description |
|--|---|
| floppy1-<release>* | JUNOS software for the M-40 when using the LS-120 external drive. |
| floppy2-<release>* | |
| install-media* | JUNOS software for the M-series, MX-series, T-series, and TX Matrix routing platforms. |
| junos-jsr-<release>-export-cf<size>.gz | JUNOS software for the J-series routers. You must select the correct installation media file that corresponds to the correct CompactFlash card you are using. |

Installation Bundles

The installation bundle can be used to downgrade or upgrade the JUNOS software between minor revisions (from Release 9.1 to Release 9.2, for example). When used, the installation bundle modifies only the files required for the upgrade or downgrade between versions.



NOTE: You should only use the installation bundle under direction of a Juniper Networks support representative.

The following installation bundle files are available for download:

| Installation Bundle | Description |
|---------------------|--|
| jbundle* | JUNOS software for the M-series, MX-series, T-series, and TX Matrix routing platforms. |

Installation Modules

Installation modules are used to upgrade individual software modules within the software. For example, you can upgrade only the Routing Engine software by installing the `jroute*` installation module.



NOTE: You should only use installation module files under the direction of a Juniper Networks support representative.

The following installation module files are available for download:

| Installation Module | Description |
|-----------------------|--|
| <code>jkernel*</code> | The kernel and network tools package. This package contains the basic operating system files. |
| <code>jbase*</code> | The base package for the JUNOS software. This package contains additions to the operating system. |
| <code>jroute*</code> | The Routing Engine package. This package contains the Routing Engine software. |
| <code>jpfe*</code> | The Packet Forwarding Engine package. This package contains the PFE software. |
| <code>jdocs*</code> | The documentation package. This package contains the documentation set for the software. |
| <code>jcrypto*</code> | The encryption package. This package contains the domestic version of the security software. |
| <code>jweb*</code> | The J-Web package. This package contains the graphical user interface software for M-series, MX-series, T-series, TX Matrix, and J-series routing platforms. |

JUNOS Software Release Numbers

The JUNOS software release number represents a particular revision of the software that runs on a Juniper Networks routing platform, for example, JUNOS Release 8.5, 9.1, or 9.2. Each JUNOS software release has certain new features that complement the software processes that support Internet routing protocols, control the router's interfaces and the router chassis itself, and allow router system management. On the Juniper Networks Support Web page, you download JUNOS software for a particular JUNOS software release number.

The following example shows how the software release number is formatted:

m.nZb.s

For example:

9.2R1.8

Where:

- *m* is the major release number of the product
- *n* is the minor release number of the product
- *Z* is the type of software release. The following release types are used:
 - **R**—Released software
 - **B**—Beta release software
 - **I**—Internal release software
- *b* is the build number of the product
- *s* is the spin number of the product

JUNOS Feature Licenses

To enable some JUNOS software features or router scaling levels, you might have to purchase, install, and manage separate software license packs. Software license keys enable you to configure and use certain features or configure a feature to a predetermined scaling level.

For information about using JUNOS licenses, see “Installing and Managing JUNOS Software Licenses” on page 59.

Software Package Information Security

All JUNOS software is delivered in signed packages that contain digital signatures, Secure Hash Algorithm (SHA-1), and Message Digest 5 (MD5) checksums. A package is installed only if the checksum within it matches the hash recorded in its corresponding file. Which checksum is used depends on the software version:

- Digital signatures are used when you upgrade or downgrade between JUNOS Release 7.0 and a later version.
- The SHA-1 checksum is used when you upgrade or downgrade between JUNOS Release 6.4 and a later version.
- The MD5 checksum is used when you upgrade or downgrade between JUNOS Release 6.3 or earlier and a later version.

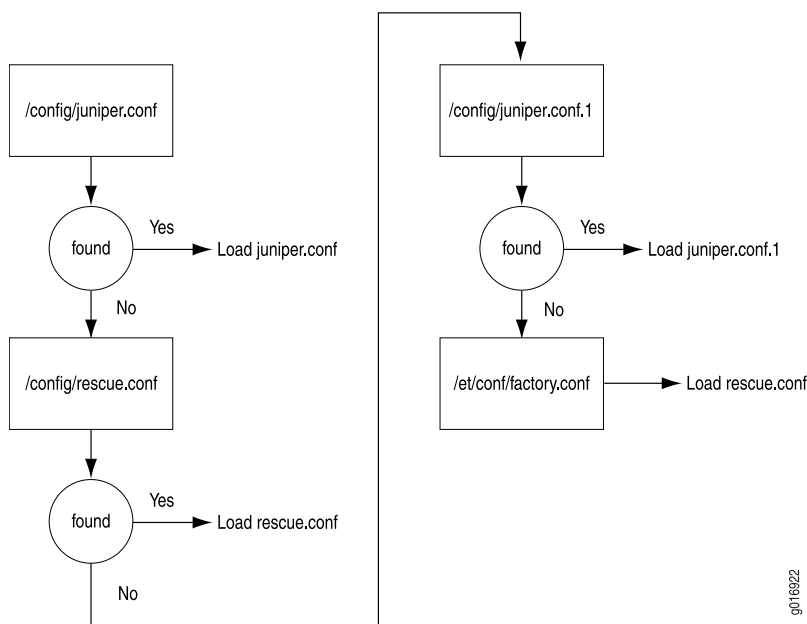
Configuration Files

All configuration settings for the router are handled in the configuration files on the router. These files are saved in the `/config` directory on the router.

Configuration File Selection Sequence

During the boot process, the router is configured based on a predefined configuration file. The router selects the configuration file based on the sequence shown in Figure 3 on page 18:

Figure 3: Configuration Selection Sequence



1. `/config/juniper.conf`—Active configuration file.
2. `/config/rescue.conf`—Rescue configuration file. This file is created by the router administrator.
3. `/config/juniper.conf.1`—First rollback configuration.
4. `/etc/config/factory.conf`—Default factory configuration file.

The `factory.conf` file is the initial router configuration file shipped with the system. All configuration settings are returned to the factory default, and access to the router is restricted to the console. For more information on setting up your router from the factory default configuration, see the specific hardware guide for your router.

Remote Storage of Configuration Files

Configuration files can be stored off the router. This can be helpful if the router encounters a software failure or other problem that forces you to restore the router's software. Once the software is restored, you can then reload the saved configuration file. For more information on restoring the JUNOS software, see "Load and Commit the Configuration File" on page 56.

When the configuration file is stored off the router, you can encrypt the configuration files using the Data Encryption Standard (DES) encryption algorithm.

Automatic Installation

On J-series routers, you can specify a remote server where configuration files are located. If a configuration file cannot be found on the router's CompactFlash card, the router automatically retrieves the configuration file from this remote server. For security purposes, you can encrypt these remote files using the DES cipher, and once they have been retrieved, the router decrypts them for use on the server.

To encrypt the files, we recommend the openssl tool. You can get the openssl tool at: <http://www.openssl.org/>. To encrypt the file, use the following syntax:

```
% openssl enc -des -k passphrase -in original-file -out encrypted-file
```

- *passphrase*—Passphrase used to encrypt the configuration file. The passphrase should be the name of the file without the path information or file extension.
- *original-file*—Unencrypted configuration file.
- *encrypted-file*—Name of the encrypted configuration file.

For example, if you are encrypting the active configuration file `juniper.conf.gz`, the passphrase is `juniper.conf`. The openssl syntax used to encrypt the file is:

```
% openssl enc -des -k juniper.conf -in juniper.conf.gz -out juniper.conf.gz.enc
```

For more information about the automatic installation feature, see the *J-series Services Router Administration Guide*.

Part 2

JUNOS Software Installation

- Installation Overview on page 23
- Completing a Standard or Change Category Installation on page 29
- Completing a Recovery Installation on page 43

Chapter 2

Installation Overview

This section describes how to install a different JUNOS software version on a routing platform, for example, upgrading from JUNOS Release 8.4 to JUNOS Release 9.2. This chapter covers the different methods used to upgrade and downgrade the software and why each method is employed. It also covers the options available to you during the installation process as well as issues that you need to understand before you start an installation process.

This chapter includes the following topics:

- Installation Type Overview on page 23
- Installation Categories on page 24
- Verifying PIC Combinations on page 26

Installation Type Overview

The three types of installations used to upgrade or downgrade your routing platform are standard installation, category change, and recovery. The standard installation is the standard method of upgrading and downgrading the software. Use a category change installation when you are moving from one software category to another; for example, if you are changing the router from using the standard JUNOS software to the JUNOS-FIPS category. Perform a recovery when the software on the router is damaged or otherwise unable to accommodate a software upgrade or downgrade.

Standard Installation

A standard installation is the typical method used to upgrade or downgrade software on the server. This method uses the installation package that matches the installation package already installed on the system. For example, you might upgrade an M-120 router running the JUNOS software installed using the `jinstall*` installation package. If you upgrade the router from the 9.0R2.10 release to the 9.1R1.8 release, you use the `jinstall-9.1R1.8-domestic-signed.tgz` installation package.

For information on the different installation packages available, see “JUNOS Installation Packages” on page 14. For instructions on performing a standard installation, see “Completing a Standard or Change Category Installation” on page 29.

Category Change Installation

The category change installation process is used to move from one category of the JUNOS software to another on the same router; for example, moving from a JUNOS standard installation on a M-, MX-, or T-series routing platforms to a JUNOS FIPS installation. When moving from one installation category to another, you need to be aware of the restrictions regarding this change.



NOTE: Juniper Networks does not support using the `request system software rollback` command to restore a different installation category on the router. When installing a different JUNOS software category on a router, once the installation is complete, you should execute a `request system snapshot` command to delete the backup installation from the system.

Recovery Installation

A recovery installation is performed to repair a router with damaged software or a condition that prevents the upgrade, downgrade, or change in installation category of the software.

For example, you may need to perform a recovery installation to change a router's software category from JUNOS-FIPS to standard JUNOS.

Installation Categories

- Installation Categories on the M-series, MX-series, T-series, and TX Matrix Routing Platforms on page 24
- Installation Categories on the J-series Routing Platforms on page 25

Installation Categories on the M-series, MX-series, T-series, and TX Matrix Routing Platforms

The following installation categories are available with the M-series, MX-series, T-series, and TX Matrix routing platforms:

- Standard JUNOS software, domestic—`jinstall-<release>-domestic-signed.tgz`

This software includes high-encryption capabilities for data leaving the router. Because of U.S. government export restrictions, this software can only be installed on systems within the United States and Canada. Furthermore, no router can be shipped out of the United States or Canada without the domestic edition first being overwritten by the export edition. There are no current system-enforced restrictions when you install this software category.

- Standard JUNOS software, export—`jinstall-<release>-export-signed.tgz`

This software does not include high-encryption capabilities. It can be installed on any system worldwide. There are no current system-enforced restrictions when you install this software category.

- JUNOS-FIPS—`junos-juniper-<release>-domestic-signed.tgz` and `junos-juniper-<release>-fips-signed.tgz`

The JUNOS-FIPS software base provides customers with the software tools to configure the router for use within a Federal Information Processing Standards (FIPS) environment. Once you have installed this software category onto a router, you cannot install a different software category on the router using the **request system software add** command. When attempting to install a different JUNOS software category package on the router, you receive the following warning message:

WARNING: Package `jinstall-<release>-<edition>-signed` is not compatible with this system.

WARNING: Please install a supported package (`junos-juniper-*.tgz`).

To return to a standard JUNOS software category installation, you must perform a system recovery installation of the software. All configuration files, logs, and other data files on the server are overwritten during a recovery installation.

For more information on the JUNOS-FIPS software base, see “FIPS 140-2 Security Compliance” on page 13.



NOTE: When you install a JUNOS software installation package, the previous installation is maintained as a backup installation. You should issue a **request system software snapshot** command to overwrite the backup files any time you change software categories on a router. This is mandatory if the router is to be shipped outside of the United States or Canada after the Export edition of the JUNOS software has been installed. There are no current system-enforced restrictions when installing this software category,

Installation Categories on the J-series Routing Platforms

The following installation categories are available with the J-series routing platforms:

- JUNOS software, domestic—`junos-jsr-<release>-domestic.tgz`

This software includes high-encryption capabilities for data leaving the router. Because of U.S. Government export restrictions, this software can only be installed on systems within the United States and Canada. Furthermore, no router can be shipped out of the U.S. or Canada without first overwriting the domestic edition with the worldwide edition. There are no current system-enforced restrictions when you install this software category.

- JUNOS, export—`junos-jsr-<release>-export.tgz`

This software does not include high-encryption capabilities. It can be installed on any system worldwide. There are no current system-enforced restrictions when you install this software category.

Verifying PIC Combinations

On Juniper Networks routing platforms, you can typically install any combination of Physical Interface Cards (PICs) on a single Enhanced Flexible PIC Concentrator (FPC) or in two PIC slots served by a single Layer 2/Layer 3 Packet Processing application-specific integrated circuit (ASIC).

Newer JUNOS services for some PICs can require significant Internet Processor ASIC memory, and some configuration rules limit certain combinations of PICs if they are installed on some platforms.

During software installation, the configuration checker in the installation program checks the router's PICs. If any configuration rules affect your PIC combinations, the installation process stops and displays a message similar to the following:

```
The combination of PICS in FPC slot 3 is not supported with this release
  PIC slot 0 -
  PIC slot 1 - 1x OC-12 ATM-II IQ
  PIC slot 2 - 1x G/E IQ, 1000 BASE
  PIC slot 3 - 1x Link Service (4)
If you continue the installation, one or more PICs on
FPC slot 3 might appear to be online but
cannot be enabled and cannot pass traffic with this release of JUNOS.
See the Release Notes for more information.
WARNING: This installation attempt will be aborted. If you
WARNING: wish to force the installation despite these warnings
WARNING: you may use the 'force' option on the command line.
pkg_add: package /var/tmp/jbundle-7.6R1.x-domestic-signed.tgz fails requirements
- not installed
```

The configuration checker has the following limitations:

- If a PIC is offline when you upgrade the router with new software, the configuration checker cannot detect PIC combinations affected by configuration rules and cannot warn about them.
- If you specify the **force** option when you upgrade the JUNOS software, the configuration checker warns about the affected PIC combination and the software installation continues. However, after rebooting, one or more PICs might fail to initialize.
- The configuration checker looks for combinations of three affected PICs. If an Enhanced FPC contains four affected PICs, the script generates multiple warnings.

If you install a PIC into a router already running JUNOS software, you can identify the presence of affected PIC combinations from messages in the system logging (syslog) file:

```
Feb 6 17:57:40 CE1 feb BCHIP 0: uCode overflow - needs 129 inst space to load
b3_atm2_LSI_decode for stream 12
Feb 6 17:57:41 CE1 chassisd[2314]: CHASSISD_IFDEV_DETACH_PIC:
ifdev_detach_pic(0/3)
Feb 6 17:57:41 CE1 feb BCHIP 0: binding b3_atm2_LSI_decode to stream 12 failed
Feb 6 17:57:41 CE1 feb PFE: can not bind B3 ucode prog b3_atm2_LSI_decode to FPC
0: stream 12
```

For more information about checking for unsupported PIC combinations, see the corresponding PIC guide for your router, the *JUNOS Release Notes*, and *Technical Support Bulletin PSN-2004-12-002, PIC Combination Notes Summary* on the Juniper Networks Support Web site at <http://www.juniper.net/support/>.

Chapter 3

Completing a Standard or Change Category Installation

This chapter describes how to perform a standard or change category installation of the JUNOS software.

For information about JUNOS software media and packages, see “Introduction” on page 3. For information on the installation process, see “Installation Overview” on page 23



NOTE: When you upgrade from a previous installation of the JUNOS software to Release 8.4R1 or later on an MX-series router, the MAC addresses on the Dense Port Concentrator’s (DPCs) Ethernet ports change.

The change category installation process is used to move from one version of the JUNOS software to another. For example, you can move from standard JUNOS on an M-series router to the export version of JUNOS. When performing a software category change, you need to take special precautions during the installation. These precautions eliminate the previous installation and prevent users from rolling back the server to these older installations.

This chapter discusses the following topics:

- Confirming That the Current Configuration Is Compatible with the Candidate Software on page 30
- Determining Which JUNOS Software Version Is Running on page 30
- Downloading Software on page 30
- Connecting to the Console Port on page 32
- Backing Up the Current Installation on page 32
- Installing the Software on page 34
- Upgrading Individual Software Packages on page 39
- Upgrading Routers Using ISSU on page 41

Confirming That the Current Configuration Is Compatible with the Candidate Software

When you upgrade or downgrade JUNOS software, we recommend that you include the `validate` option with the `request system software add` command to check that the candidate software is compatible with the current configuration. By default, when you add a package with a different release number, the validation check is done automatically. For more information about the `request system software add` command, see the *JUNOS System Basics and Services Command Reference*.

Determining Which JUNOS Software Version Is Running

To determine which packages are running on the router and to get information about these packages, use the `show version` operational mode command at the top level of the command-line interface (CLI).



NOTE: The `show version` command does not show the software category installed, only the release number of the software.

Downloading Software

You can download the software in one of two ways: downloading the file in a browser or using FTP on the command line:

- Downloading Software with a Browser on page 30
- Downloading Software Using the Command-Line Interface on page 31

Downloading Software with a Browser

You download the software package you need from the Juniper Networks Support Web site at <http://www.juniper.net/support/>.



NOTE: To access the download section, you must have a service contract and an access account. If you need help obtaining an account, complete the registration form at the Juniper Networks Web site: <https://www.juniper.net/registration/Register.jsp>.

To download the software:

1. In a browser, go to <http://www.juniper.net/support/>.

The Support page opens.

2. In the Download Software section, select the software version to download.

Depending on your location, select JUNOS Canada and US, or JUNOS Worldwide.

3. Select the current release to download.
4. Click the Software tab and select the JUNOS Installation Package to download.

A dialog box opens.

5. Save the file to your system. If you are placing the file on a remote system, you must make sure that the file can be accessible by the router using the HTTP, FTP, or SCP protocol.

Downloading Software Using the Command-Line Interface

You download the software package you need from the Juniper Networks Support Web site at <http://www.juniper.net/support/>.



NOTE: To access the download section, you must have a service contract and an access account. If you need help obtaining an account, complete the registration form at the Juniper Networks Web site: <https://www.juniper.net/registration/Register.jsp>.

To download the software:

1. On the command line, initiate an FTP session with the server **ftp.juniper.net**:

ftp ftp.juniper.net

2. Log in with your customer support-supplied username and password:

```
User <black.juniper.net:<none>>: username
331 Password required for username.
Password: password
```

Once validated, the FTP session opens.

3. Navigate to the correct software directory.

The FTP server software download structure is as follows:

```
/volume/download/docroot/software/<version>/<release>
```

Available directories include:

- **version**—The software version.
 - junos
 - junos-export
 - junos-fips
- **release**—The software release. For more information on release numbers, see “JUNOS Software Release Numbers” on page 16.

4. Set the file transfer mode to binary:

```
bin
Type set to 1.
```

5. Specify the directory in which you wish to place the file.

On Juniper Networks servers running the JUNOS operating system, installation files are typically placed in the `/var/tmp` directory. If you are placing the file on a remote system, you must make sure that the file can be accessed by the router using HTTP, FTP, or SCP.

```
lcd /var/tmp  
Local directory now /var/tmp.
```

6. Download the installation file:

```
get <filename>
```

7. Close the FTP session:

```
bye  
Goodbye.
```

Connecting to the Console Port

The console port is a data terminal equipment (DTE) interface, providing a direct and continuous interface with the router. It is important to connect to the console during installation procedures so you can respond to any required user input and detect any errors that may occur.

For more information about connecting to the console port, see the administration guide for your particular router.

Backing Up the Current Installation

You should back up the current installation so that you can return to the current software installation. In a dual Routing Engine system, you need to back up both Routing Engines. This section covers the following:

- Backing Up M-series, MX-series, T-series, and TX Matrix Routing Platforms on page 32
- Backing Up J-series Routers on page 33

Backing Up M-series, MX-series, T-series, and TX Matrix Routing Platforms

The installation process using the installation package (`jinstall*`, for example) removes all stored files on the router except the `juniper.conf` and SSH files. Therefore, you should back up your current configuration in case you need to return to the current software installation after running the installation program.

To back up the JUNOS software on the M-series, MX-series, T-series, and TX Matrix routing platforms, issue the **request system snapshot** CLI operational command. This command saves the current software installation on the hard drive.



NOTE: On M-series, MX-series, T-series, and TX Matrix routing platforms with dual Routing Engines, complete this operation on both Routing Engines. On routers without a CompactFlash card, where the hard drive is the primary boot device, you cannot back up your software installation.

When the **request system snapshot** command is issued, the **/root** file system is backed up to **/altroot**, and **/config** is backed up to **/altconfig**. The **/root** and **/config** file systems are on the router's CompactFlash card, and the **/altroot** and **/altconfig** file systems are on the router's hard disk. When the backup is completed, the current and backup software installations are identical.

To copy the files to the router's hard disk, use the following command:

```
user@host> request system snapshot
```

Backing Up J-series Routers

The installation process using the installation package (**junos-jsr***) removes all stored files on the router except the **juniper.conf** and SSH files. Therefore, you should back up your current configuration in case you need to return to the current software installation after running the installation program.

These instructions offer the minimum steps required to create a backup during the installation process. For a complete description of the backup process on the J-series routers, see the *J-series Services Router Administration Guide* and the *JUNOS Software Systems Basics Configuration Guide*.

To back up the JUNOS software on the J-series routers:

1. Attach an external memory device to the router.



NOTE: Even when attached to a J-series router,, a USB memory device is not listed as a storage device using the CLI command **show system storage**. You can view the installed USB memory device on the J-Web interface's system monitor screen.

2. Issue the **request system snapshot media usb** command.

The current software installation and configuration are saved on the external USB storage device.

Installing the Software

Once you have backed up the current installation, you are ready to upgrade or downgrade your software:

- Installing the Software Package on a Router with a Single Routing Engine on page 34
- Installing the Software Package on a Router with Redundant Routing Engines on page 35

Installing the Software Package on a Router with a Single Routing Engine

To upgrade the router software, follow these steps:

1. Install the new software package using the **request system software add** command:

```
user@host> request system software add /var/tmp/installation-package
```

installation-package is the name of the installation package; for example *jinstall-9.2R1.8-domestic-signed.tgz*

For more information about the **request system software add** command, see the *JUNOS System Basics and Services Command Reference*.

2. Reboot the router to start the new software using the **request system reboot** command:

```
user@host> request system reboot
Reboot the system? [yes, no] (no) yes
```



NOTE: You must reboot the device to load the new installation of the JUNOS software on the device.

To abort the installation, do not reboot the device; instead, finish the installation and then issue the **request system software delete jinstall** command. This is your last chance to stop the installation.

The software is loaded when you reboot the system. Installation can take between 5 and 10 minutes. The router then reboots from the boot device on which the software was just installed. When the reboot is complete, the router displays the login prompt.

While the software is being upgraded, the Routing Engine on which you are performing the installation does not route traffic.

3. Log in and issue the **show version** command to verify the version of the software installed.
4. (Optional) Add the **jweb** package using the **request system software add** command. Before you can add this package, you must first download the software as you did the installation package. For more information on downloading the **jweb** package, see “Downloading Software” on page 30.

The **jweb** installation module adds a router management graphical user interface that you can use to view and configure your router. For more information about the **jweb** package, see “Installation Modules” on page 16.

5. After you have upgraded or downgraded the software and are satisfied that the new software is successfully running, issue the **request system snapshot** command to back up the new software.

Installing the Software Package on a Router with Redundant Routing Engines

If the router has two Routing Engines, perform a JUNOS software installation on each Routing Engine separately to avoid disrupting network operation. Install the new JUNOS software release on the backup Routing Engine while keeping the currently running software version on the master Routing Engine. After making sure that the new software version is running correctly on the backup Routing Engine, switch over to the newly installed Routing Engine to activate the new software. Finally, install the new software on the new backup Routing Engine.



WARNING: If graceful Routing Engine switchover (GRES) is enabled when you initiate a software installation, the software does not install properly. Make sure you issue the CLI **delete chassis redundancy** command when prompted. If GRES is enabled, it will be removed with the **redundancy** command.

To upgrade the router software, perform the following tasks:

- Preparing the Router for the Installation on page 35
- Installing Software on the Backup Routing Engine on page 36
- Installing Software on the Primary Routing Engine on page 37
- Finalizing the Installation on page 38

Preparing the Router for the Installation

Perform the following steps before installing the software:

1. Log in to the master Routing Engine’s console.

For more information on logging in to the Routing Engine through the console port, see the administration manual for your particular router.

2. Enter the JUNOS software CLI configuration mode:

- a. Start the CLI from the shell prompt:

```
# cli
user@host>
```

- b. Enter configuration mode:

```
user@host#> configure
Entering configuration mode

[edit]
```

```
user@host#
```

3. Disable Routing Engine redundancy:

```
[edit]
user@host# delete chassis redundancy
```

4. Save the configuration change on both Routing Engines:

```
[edit]
user@host# commit synchronize
```

5. Exit out of the CLI configuration mode:

```
[edit]
user@host# exit
```

Installing Software on the Backup Routing Engine

Once the router is ready, you first install the software on the backup Routing Engine. This enables the primary Routing Engine to continue operations, minimizing the disruption to your network.

1. Log in to the backup Routing Engine's console:

For more information on logging in to the Routing Engine through the console port, see the administration manual for your particular router.

2. Install the new software package using the **request system software add** command:

```
user@host> request system software add validate  
/var/tmp/jinstall-9.2R1.8-domestic-signed.tgz
```

For more information on the **request system software add** command, see the *JUNOS System Basics and Services Command Reference*.

3. Reboot the router to start the new software using the **request system reboot** command:

```
user@host> request system reboot  
Reboot the system? [yes, no] (no) yes
```



NOTE: You must reboot the device to load the new installation of the JUNOS software on the router.

To abort the installation, do not reboot your device, instead, finish the installation and then issue the **request system software delete jinstall** command. This is your last chance to stop the installation.

All the software is loaded when you reboot the device. Installation can take between 5 and 10 minutes. The router then reboots from the boot device on which the software was just installed. When the reboot is complete, the router displays the login prompt.

While the software is being upgraded, the Routing Engine on which you are performing the installation is not routing traffic.

4. Log in and issue the **show version** command to verify the version of the software installed.
5. (Optional) Add the **jweb** package using the **request system software add** command. Before you can add this package, you must first download the software as you did the installation package. For more information on downloading the **jweb** package, see “Downloading Software” on page 30.

The **jweb** installation module adds a router management graphical user interface that you can use to view and configure your router. For more information about the **jweb** package, see “Installation Modules” on page 16.

Installing Software on the Primary Routing Engine

Once the software is installed on the backup Routing Engine, you are ready to switch routing control to the backup Routing Engine and then upgrade or downgrade the primary Routing Engine software:

1. Log in to the primary Routing Engine console port.

For more information on logging in to the Routing Engine through the console port, see the administration guide for your particular router.

2. Transfer routing control to the backup Routing Engine:

```
user@host> request chassis routing-engine master switch
```

3. Verify that the backup Routing Engine (slot 1) is the master Routing Engine:

```
user@host> show chassis routing-engine
Routing Engine status:
Slot 0:
  Current state      Backup
  Election priority  Master (default)
Routing Engine status:
Slot 1:
  Current state      Master
  Election priority  Backup (default)
```

4. Install the new software package using the **request system software add** command:

```
user@host> request system software add validate
/var/tmp/jinstall-9.2R1.8-domestic-signed.tgz
```

For more information about the **request system software add** command, see the *JUNOS System Basics and Services Command Reference*.

5. Reboot the Routing Engine using the **request system reboot** command:

```
user@host> request system reboot
Reboot the system? [yes, no] (no) yes
```



NOTE: You must reboot to load the new installation of the JUNOS software on the router.

To abort the installation, do not reboot your system; instead, finish the installation and then issue the **request system software delete jinstall** command. This is your last chance to stop the installation.

The software is loaded when you reboot the system. Installation can take between 5 and 10 minutes. The router then reboots from the boot device on which the software was just installed. When the reboot is complete, the router displays the login prompt.

While the software is being upgraded, the Routing Engine on which you are performing the installation does not route traffic.

6. Log in and issue the **show version** command to verify the version of the software installed.
7. (Optional) Add the **jweb** package using the **request system software add** command. Before you can add this package, you must first download the software as you did the installation package. For more information on downloading the **jweb** package, see “Downloading Software” on page 30.

The **jweb** installation module adds a router management graphical user interface that you can use to view and configure your router. For more information about the **jweb** package, see “Installation Modules” on page 16.

8. Transfer routing control back to the master Routing Engine:

```
user@host> request chassis routing-engine master switch
```

9. Verify the master Routing Engine (slot 0) is indeed the master Routing Engine:

```
user@host> show chassis routing-engine
Routing Engine status:
Slot 0:
  Current state      Master
  Election priority  Master (default)
Routing Engine status:
Slot 1:
  Current state      Backup
  Election priority  Backup (default)
```

Finalizing the Installation

Once the software is installed on both Routing Engines, you return the router back to its original configuration and back up the new installation.

1. Restore the configuration that existed before you deleted it at the start of this procedure:

```
{backup}
user@host-re0> configure
```

```
[edit]
user@host-re0# rollback 1
```

2. Save the configuration change on both Routing Engines:

```
[edit]
user@host-re0> commit synchronize and-quit
```

3. After you have installed the new software and are satisfied that it is successfully running, issue the **request system snapshot** command to back up the new software on both master and backup Routing Engines:

```
{master}
user@host-re0> request system snapshot
{master}
user@host-re0> request routing-engine login other routing-engine
{backup}
user@host-re1> request system snapshot
{backup}
```

The root file system is backed up to `/altroot`, and `/config` is backed up to `/altconfig`. The root and `/config` file systems are on the router's CompactFlash card, and the `/altroot` and `/altconfig` file systems are on the router's hard disk.



NOTE: After you issue the **request system snapshot** command, you cannot return to the previous version of the software because the running copy and backup copy of the software are identical.

Upgrading Individual Software Packages



NOTE: When you install individual software packages, the following notes apply:

- When upgrading from JUNOS Release 8.2 or earlier to JUNOS Release 8.5, use the **system software add <image> no-validate** command option.
 - Only use the **jinstall** JUNOS software image when upgrading or downgrading to or from JUNOS Release 8.5. Do not use the **jbundle** image.
 - Before upgrading to JUNOS Release 8.5, ensure that the routing platform's CompactFlash card is 256 MB or larger to avoid disk size restrictions. (M7i routers without a CompactFlash card are excluded.)
-

To upgrade an individual JUNOS software package, follow these steps:

1. Download the software packages you need from the Juniper Networks Support Web site at <http://www.juniper.net/support/>. Choose either the Canada and U.S. Version or the Worldwide Version.

To download the software packages, you must have a service contract and an access account. If you need help obtaining an account, complete the registration form at the Juniper Networks Web site:
<https://www.juniper.net/registration/Register.jsp>.



NOTE: We recommend that you upgrade all individual software packages using an out-of-band connection from the console or **fxp0** interface, because in-band connections can be lost during the upgrade process.

2. Back up the currently running and active file system so that you can recover to a known, stable environment in case something goes wrong with the upgrade:

```
user@host> request system snapshot
```

The root file system is backed up to **/altroot**, and **/config** is backed up to **/altconfig**. The root and **/config** file systems are on the router's CompactFlash card, and the **/altroot** and **/altconfig** file systems are on the router's hard disk.



NOTE: After you issue the **request system snapshot** command, you cannot return to the previous version of the software, because the running copy and the backup copy of the software are identical.

3. If you are copying multiple software packages to the router, copy them to the **/var/tmp** directory on the hard disk:

```
user@host> file copy ftp://username :prompt@ftp.hostname
.net/filename/var/tmp/filename
```

4. Add the new software package:

```
user@host> request system software add/var/tmp/ installation package validate
```

package-name is the full URL to the file.

The system might display the following message:

```
pkg_delete: couldn't entirely delete package
```

This message indicates that someone manually deleted or changed an item that was in a package. You do not need to take any action; the package is still properly deleted.

If you are upgrading more than one package at the same time, add jbase first. If you are using this procedure to upgrade all packages at once, add them in the following order:

```
user@host> request system software add /var/tmp/jbase-release-signed.tgz
user@host> request system software add /var/tmp/jkernel-release-signed.tgz
user@host> request system software add /var/tmp/jpfe-release-signed.tgz
user@host> request system software add /var/tmp/jdocs-release-signed.tgz
user@host> request system software add /var/tmp/jweb-release-signed.tgz
user@host> request system software add /var/tmp/jroute-release-signed.tgz
user@host> request system software add /var/tmp/jcrypto-release-signed.tgz
```

5. Reboot the router to start the new software:

```
user@host> request system reboot
```

6. After you have upgraded or downgraded the software and are satisfied that the new software is successfully running, issue the `request system snapshot` command to back up the new software:

```
user@host> request system snapshot
```

The root file system is backed up to `/altroot`, and `/config` is backed up to `/altconfig`. The root and `/config` file systems are on the router's CompactFlash card, and the `/altroot` and `/altconfig` file systems are on the router's hard disk.



NOTE: After you issue the `request system snapshot` command, you cannot return to the previous version of the software, because the running copy and backup copy of the software are identical.

Upgrading Routers Using ISSU

Unified in-service software upgrade (ISSU) enables you to upgrade between two different JUNOS software releases with no disruption on the control plane and with minimal disruption of traffic. ISSU is only supported by dual Routing Engine platforms. In addition, graceful Routing Engine switchover (GRES) and nonstop active routing (NSR) must be enabled.

For additional information about using ISSU, see the *JUNOS High Availability Guide*.

Chapter 4

Completing a Recovery Installation

If the router's software is corrupted or otherwise damaged, you may need to perform a recovery installation, using the emergency boot disk to restore the default factory installation. Once you have recovered the software in this fashion, you must configure the router as you would for a new router.

This chapter discusses the following topics:

- Creating an Emergency Boot Disk on page 43
- Saving a Rescue Configuration File on page 44
- Performing a Recovery Installation on page 45

Creating an Emergency Boot Disk

If the router's JUNOS software is damaged in some way that prevents the JUNOS software from loading completely, you can use the emergency boot disk to revive the router. The emergency boot disk repartitions the primary disk and reloads a fresh installation of the JUNOS software.

The procedures outlined in this section discuss how to create an emergency boot disk for any M-series, MX-series, T-series, or TX Matrix routing platform.

To create an emergency boot disk:

1. Use FTP to copy the installation media into the router's `/var/tmp` directory.
2. Insert the PC Card into the external PC Card slot.
3. In the UNIX shell, navigate to the `/var/tmp` directory:

```
start shell
cd /var/tmp
```

4. Log in as su:

```
su [enter]
password: [enter SU password]
```

5. issue the following commands:

```
dd if=/dev/zero of=/dev/externalDrive count=20
dd if=installMedia of=/dev/externalDrive bs=64k
```

where:

- *externalDrive*—Refers to the removable media name. For example, the removable media name on the M120 is *da0* for both Routing Engines. For the names of the storage media, see Table 7 on page 9.
- *installMedia*—Refers to the installation media downloaded into the */var/tmp* directory. For example, *install-media-9.0R2.10-domestic.tgz*.

The following code example can be used to create an emergency boot disk using a PC Card on an M20 router:

```
dd if=/dev/zero of=/dev/ad3 count=20
dd if=install-media-9.0R2.10-domestic.tgz of=/dev/ad3 bs=64k
```

The following code example can be used to create an emergency boot disk using a USB storage device on an M120 router:

```
dd if=/dev/zero of=/dev/da0 count=20
dd if=install-media-9.0R2.10-domestic.tgz of=/dev/da0 bs=64k
```

6. Log out as su:

```
exit
```

Saving a Rescue Configuration File

A rescue configuration file is helpful in the event that your router's configuration file has been misconfigured. You can restore the router to this rescue configuration to bring the router back online. If you save this file off the router, the rescue configuration can also be used to restore your router in the event of a software failure.

To save a current router configuration as a rescue configuration file:

1. Edit the configuration file on the router to reflect the base configuration you wish to use.

For more information about editing the configuration, see the *JUNOS System Basics Guide*.

2. In the CLI operational mode, save this edited base configuration as the rescue configuration file:

```
user@host> request system configuration rescue save
```

3. Copy the rescue configuration to a remote server:

```
user@host> ftp host
Name: username
Password: password
230 User user logged in.
ftp> cd /filepath
ftp> lcd /config
ftp> bin
Type set to I.
```



```
ftp> put rescue.conf.gz
Transfer complete.
ftp> bye
Goodbye.
```

Performing a Recovery Installation

To perform a recovery installation, perform the following tasks:

- Preparing to Reinstall the JUNOS Software on page 45
- Reinstalling the JUNOS Software on page 45
- Restoring the Router's Configuration on page 46

Preparing to Reinstall the JUNOS Software

Depending on the situation, you should try to perform the following steps before you perform the recovery installation:

1. Ensure you have an emergency recovery disk to use during the installation. When the router is first shipped, an emergency recovery disk is provided with it. For instructions on creating an emergency boot disk, see "Creating an Emergency Boot Disk" on page 43
2. Copy the existing configuration in the file `/config/juniper.conf.gz` from the router to a remote system. For extra safety, you can also copy the backup configurations (the files named `/config/juniper.conf.n`, where *n* is a number from 0 through 9).



WARNING: The recovery installation process completely overwrites the entire contents of the fixed storage media.

3. Copy any other stored files to a remote system as desired.

Reinstalling the JUNOS Software

To reinstall the JUNOS software:

1. Insert the removable media into the router.



NOTE: You can store a configuration on installation media such as a PC Card.

2. Reboot the router. Do not power off the router if it is already on. Issue the CLI `request system reboot` command.
3. When the software prompts you with the following question, type **y**:

```
WARNING: The installation will erase the contents of your disk. Do you
wish to continue (y/n)? y
```

4. The router copies the software from the removable media onto your system, occasionally displaying status messages. Copying the software can take up to 10 minutes.
5. Remove the removable media when prompted. The router then reboots from the boot device on which the software was just installed. When the reboot is complete, the router displays the login prompt.

Restoring the Router's Configuration

Once you have restored the JUNOS software, you will need to restore the router's configuration. You can either create a new configuration as you did when the router was shipped from the factory, or if you saved the router's previous configuration, you can simply restore that file to the system:

- Creating a New Configuration on a Single Routing Engine on page 46
- Creating a New Configuration with Redundant Routing Engines on page 50
- Restoring a Saved Configuration on page 55

Creating a New Configuration on a Single Routing Engine

To create a new base configuration on a single routing engine:

- Log In to the Router Console on page 46
- Configure Administration User Accounts on page 47
- Add the Management Console to the Network on page 47
- Commit Changes on page 48

Log In to the Router Console

To log in to the router's console interface and open the CLI in configuration mode:

1. Verify the router is powered on.
2. Log in through the console port as root.

```
Amnesiac <ttyd0>
```

```
login: root
```



NOTE: From the factory, the root administration user account is not associated with a password. However, you must add a password to the root administration account before you can successfully commit a configuration.

3. Start the CLI, which initially opens in operational mode. Note the command prompt ends with > in the CLI operational mode.

```
root@% cli
root>
```

4. Enter the CLI configuration mode. Note the command prompt ends with # in the CLI configuration mode.

```
root> configure
[edit]
root#
```

Configure Administration User Accounts

Set the root administration user account password. You also need to set up one or more administration user accounts. These administration user accounts are used to log in to the router through the management console. To configure administration user accounts:

1. Add a password to the root (superuser) administration user account.

```
[edit]
root# set system root-authentication plain-text-password
New password: password
Retype new password: password
```

2. Create a management console user account.

```
[edit]
root# set system login user user-name authentication plain-text-password
New Password: password
Retype new password: password
```

3. Set the user account class to super-user.

```
[edit]
root# set system login user user-name class super-user
```

Add the Management Console to the Network

To add the management console to the network:

1. Specify the router host name.



NOTE: This host name specified in the router configuration is not used by the DNS server to resolve to the correct IP address. This host name is used to display the name of the routing engine in the CLI. For example, this host name shows on the command line prompt when the user is logged on to the CLI:

```
user-name@host-name>
```

```
[edit]
root# set system host-name host-name
```

2. Configure the IP address of the DNS server.

```
[edit]
root# set system name-server address
```

3. Configure the router domain name.

```
[edit]
root# set system domain-name domain-name
```

4. Configure the IP address and prefix length for the router Ethernet interface.

```
[edit]
root# set interfaces fxp0 unit 0 family inet address address/prefix-length
```

5. Configure the IP address of a backup router. The backup router is used while the local router is booting and if the routing process fails to start. Once the routing process starts, the backup router address is removed from the local routing and forwarding tables. For more information on the backup router, see the *JUNOS System Basics Configuration Guide*.

```
[edit]
root# set system backup-router address
```

6. (Optional) Configure the static routes to remote subnets with access to the management port. Access to the management port is limited to the local subnet. To access the management port from a remote subnet, you need to add a static route to that subnet within the routing table. For more information on static routes, see the *JUNOS System Basics Configuration Guide*.

```
[edit]
root# set routing-options static route remote-subnet next-hop destination-IP retain no-readvertise
```

7. Configure the telnet service at the [edit system services] hierarchy level.

```
[edit]
root# set system services telnet
```

Commit Changes

Now that you have completed your changes to the configuration file, commit the configuration changes.

1. Before committing the configuration, you can review your changes to the configuration with the **show** command.

```
root# show
## Last changed: 2008-08-27 22:30:42 UTC
version 9.3B1.5;
system {
  host-name tp8;
  domain-name subnet.juniper.net;
  backup-router 192.168.71.254;
  root-authentication {
    encrypted-password "xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx."; ## SECRET-DATA
  }
}
```

```

name-server {
    192.168.5.68;
    172.17.28.101;
}
login {
    user regress {
        class super-user;
        authentication {
            encrypted-password "xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx"; ##
SECRET-DATA
        }
    }
}
services {
    telnet;
}
syslog {
    user * {
        any emergency;
    }
    file messages {
        any notice;
        authorization info;
    }
    file interactive-commands {
        interactive-commands any;
    }
}
}
interfaces {
    fxp0 {
        unit 0 {
            family inet {
                address 192.128.69.205/21;
            }
        }
    }
}
routing-options {
    static {
        route 172.16.0.0/12 {
            next-hop 192.168.71.254;
            retain;
            no-readvertise;
        }
        route 192.168.0.0/16 {
            next-hop 192.168.71.254;
            retain;
            no-readvertise;
        }
    }
}
}

```

2. Commit the configuration.

[edit]

```
root# commit
commit complete
```

**NOTE:**

If you receive an error message after you issue the **commit** statement, you can review the configuration using the **show** command to find the errors in your configuration. You can delete incorrect entries using the **delete** command. For example, to delete a host name from the configuration, issue the following statement:

```
[edit]
root# delete system host-name host-name
```

3. Exit configuration mode.

```
[edit]
root# exit
Exiting configuration mode

root>
```

Creating a New Configuration with Redundant Routing Engines

To create a new base configuration on a router with redundant Routing Engines:

- Configure Administration User Accounts on page 50
- Set Up Routing Engine Configuration Groups on page 51
- Complete the Management Console Configuration on page 52
- Commit and Synchronize Changes on page 53

Configure Administration User Accounts

Set the root administration user account password. You also need to set up one or more administration user accounts. These administration user accounts are used to log in to the router through the management console. To configure administration user accounts:

1. Add a password to the root (superuser) administration user account.

```
[edit]
root# set system root-authentication plain-text-password
New password: password
Retype new password: password
```

2. Create a management console user account.

```
[edit]
root# set system login user user-name authentication plain-text-password
New Password: password
Retype new password: password
```

3. Set the user account class to `super-user`.

```
[edit]
root# set system login user user-name class super-user
```

Set Up Routing Engine Configuration Groups

In a router with two Routing Engines, one configuration should be shared between both Routing Engines. This ensures that both Routing Engine configurations are identical. Within this configuration, create two Routing Engine groups, one for each Routing Engine. Within these groups, you specify the Routing Engine specific parameters. For more information on creating configuration groups, see:

<http://www.juniper.net/techpubs/software/junos/junos92/swconfig-cli/creating-a-configuration-group.html#id-11110765>. For more information on the

initial configuration for redundant Routing Engine systems, see

<http://www.juniper.net/techpubs/software/junos/junos92/swconfig-high-availability/initial-routing-engine-configuration.html>.

1. Create the configuration group `re0`. The `re0` group is a special group designator that is only used by RE0 in a redundant routing platform. For more information on the `re0` group, see: <http://www.juniper.net/techpubs/software/junos/junos92/swconfig-high-availability/initial-routing-engine-configuration.html>.

```
[edit]
root# set groups re0
```

2. Navigate to the `groups re0` level of the configuration hierarchy.

```
[edit]
root# edit groups re0
```

3. Specify the router host name.

```
[edit groups re0]
root# set system host-name host-name
```



NOTE:

This host name specified in the router configuration is not used by the DNS server to resolve to the correct IP address. This host name is used to display the name of the Routing Engine in the CLI. For example, this host name appears at the command-line prompt when the user is logged on to the CLI:

```
user-name@host-name>
```

-
4. Configure the IP address and prefix length for the router Ethernet interface.

```
[edit groups re0]
root# set interfaces fxp0 unit 0 family inet address address/prefix-length
```

5. Return to the top level of the hierarchy.

```
[edit groups re0]
```

```
root# top
```

6. Create the configuration group **re1**.

```
[edit]
root# set groups re1
```

7. Navigate to the **groups re1** level of the configuration hierarchy.

```
[edit]
root# edit groups re1
```

8. Specify the router host name.

```
[edit groups re1]
root# set system host-name host-name
```

9. Configure the IP address and prefix length for the router Ethernet interface.

```
[edit groups re1]
root# set interfaces fxp0 unit 0 family inet address address/prefix-length
```

10. Return to the top level of the hierarchy.

```
[edit groups re0]
root# top
```

11. Specify the group application order.

```
[edit]root# set apply-groups [ re0 re1 ]
```

Complete the Management Console Configuration

To configure the global management console parameters.

1. Configure the IP address of the DNS server.

```
[edit]
root# set system name-server address
```

2. Configure the router domain name.

```
[edit]
root# set system domain-name domain-name
```

3. Configure the IP address of a backup router. The backup router is used while the local router is booting and if the routing process fails to start. Once the routing process starts, the backup router address is removed from the local routing and forwarding tables. For more information on the backup router, see the *JUNOS System Basics Configuration Guide*.

```
[edit]
root# set system backup-router address
```

4. (Optional) Configure the static routes to remote subnets with access to the management port. Access the management port is limited to the local subnet. To access the management port from a remote subnet, you need to add a static

route to that subnet within the routing table. For more information on static routes, see the *JUNOS System Basics Configuration Guide*.

```
[edit]
root# set routing-options static route remote-subnet next-hop destination-IP
retain no-advertise
```

5. Configure the telnet service at the [edit system services] hierarchy level.

```
[edit]
root# set system services telnet
```

Commit and Synchronize Changes

Commit the configuration changes. When you issue the **synchronize** command, the configuration is shared between both Routing Engines and committed on both Routing Engines simultaneously.

1. Before committing the configuration, you can review the configuration entries using the **show** command.

```
root# show
## Last changed: 2008-10-17 18:32:25 UTC
version 9.1R1.8;
groups {
  re0 {
    system {
      host-name spice-re0;
    }
    interfaces {
      fxp0 {
        unit 0 {
          family inet {
            address 192.168.69.155/21;
          }
        }
      }
    }
  }
  re1 {
    system {
      host-name spice-re1;
    }
    interfaces {
      fxp0 {
        unit 0 {
          family inet {
            address 192.168.70.72/21;
          }
        }
      }
    }
  }
}
global;
```

```

apply-groups [ re0 re1 ];
system {
    domain-name englab.juniper.net;
    backup-router 192.168.71.254;
    root-authentication {
        encrypted-password "xxxxxxxxxx"; ## SECRET-DATA
    }
    name-server {
        192.168.1.1;
    }
    login {
        user regress {
            uid 2001;
            class super-user;
            authentication {
                encrypted-password "xxxxxxxxxx"; ## SECRET-DATA
            }
        }
    }
    services {
        telnet;
    }
    syslog {
        user * {
            any emergency;
        }
        file messages {
            any notice;
            authorization info;
        }
        file interactive-commands {
            interactive-commands any;
        }
    }
}
routing-options {
    static {
        /* corporate office */
        route 172.16.0.0/12 {
            next-hop 192.168.71.254;
            retain;
            no-readvertise;
        }
    }
}

```

2. Commit and synchronize the configuration. The **commit synchronize** command will commit this new configuration on both Routing Engines simultaneously.

```

[edit]
root# commit synchronize
re0:
configuration check succeeds
re1:
commit complete
re0:

```

```
commit complete
```

If you receive an error message after you issue the **commit** statement, you can review the configuration using the **show** command to find the errors in your configuration. You can delete incorrect entries using the **delete** command. For example, to delete a host name from the configuration, issue the following statement:

```
[edit]
root# delete system host-name host-name
```

3. Exit configuration mode.

```
[edit]
root# exit
Exiting configuration mode

root>
```

Restoring a Saved Configuration

To restore a saved configuration, perform the following tasks:

1. Copy Saved Files to the Router on page 55
2. Load and Commit the Configuration File on page 56

Copy Saved Files to the Router

To copy the saved configuration to the router:

1. Log in to the console as root. There is no password.

```
Escape character is '^]'.
[Enter]
router (ttyd0)
```

```
login: root
Password: [Enter]
```

Initially, access to the router is limited to the console port after a recovery installation. Access through the management ports and interfaces is set in the configuration. For information about accessing the router through the console port, see the administration guide for your particular router.

2. Start the CLI:

```
# cli
```

3. Copy the remote configuration file to the router's `/var/tmp` directory:

```
root@host> ftp remote-server
user: username
password: password
ftp> bin
Type set to I.
ftp> get /path/file
```

```
ftp> bye
Goodbye.
```

Load and Commit the Configuration File

Once the saved configuration file is copied to the router, you load and commit the file:

1. Start the CLI configuration mode.

```
user@routername> configure
Entering configuration mode

[edit]
user@host#
```

2. Load the file into the current configuration. You should override the existing file.

```
user@host#
load override /var/tmp/filename
load complete
```

3. Commit the file.

```
user@host# commit
commit complete
```

4. Exit the CLI configuration mode.

```
user@host# exit
user@host>
```

5. Back up the JUNOS software.

After you have installed the software on the router, committed the configuration, and are satisfied that the new configuration is successfully running, issue the **request system snapshot** command to back up the new software to the **/altconfig** file system. If you do not issue the **request system snapshot** command, the configuration on the alternate boot drive will be out of sync with the configuration on the primary boot drive.

The **request system snapshot** command causes the root file system to be backed up to **/altroot**, and **/config** to be backed up to **/altconfig**. The root and **/config** file systems are on the router's CompactFlash card, and the **/altroot** and **/altconfig** file systems are on the router's hard disk.

Part 3

JUNOS Software Licenses

- Installing and Managing JUNOS Software Licenses on page 59

Chapter 5

Installing and Managing JUNOS Software Licenses

To enable some JUNOS software features or router scaling levels, you may need to purchase, install, and manage separate software license packs. The presence on the router of the appropriate software license keys (passwords) determines whether you can configure and use certain features or configure a feature to a predetermined scale.

For information about how to purchase JUNOS software licenses, contact your Juniper Networks sales representative.

This chapter contains the following topics:

- JUNOS License Overview on page 59
- Before You Begin on page 61
- Managing JUNOS Licenses on page 61
- Verifying JUNOS License Management on page 63

JUNOS License Overview

As an honor-based licensing structure, JUNOS feature and scaling licenses are universal, and the same feature or scaling key can be installed and configured on multiple routers. However, to conform to JUNOS feature or scale licensing requirements, you must purchase one license per router.

This section contains the following topics:

- License Enforcement on page 59
- Software Feature Licenses on page 60
- License Key Components on page 61

License Enforcement

For features or scaling levels that require a license, you must install and properly configure the license to meet the requirements for using the licensable feature or scale level. The router enables you to commit a configuration that specifies a licensable feature or scale without a license for a 30-day grace period. The grace period is a short-term grant that enables you to start using features in the pack or scale up to

the system limits (regardless of the license key limit) without a license key installed. The grace period begins when the licensable feature or scaling level is actually used by the router (not when it is first committed). In other words, you can commit licensable features or scaling limits to the router configuration, but the grace period does not begin until the router uses the licensable feature or exceeds a licensable scaling level.



NOTE: Configurations might include both licensed and nonlicensed features. For these situations, the license is enforced up to the point where the license can be clearly distinguished. For example, an authentication-order configuration is shared by both Authentication, Authorization, and Accounting (AAA), which is licensed, and by Layer 2 Tunneling Protocol (L2TP), which is not licensed. When the configuration is committed, the router does not issue any license warnings, because it is not yet known whether AAA or L2TP is using the configuration. However, at runtime, the router checks for a license when AAA authenticates clients, but does not check when L2TP authenticates clients.

The router reports any license breach as a warning log message whenever a configuration is committed that contains a feature or scale limit usage that requires a license. Following the 30-day grace period, the router periodically reports the breach to the CLI command line until a license is installed and properly configured on the router to resolve the breach.



NOTE: Successful commitment of a licensable feature or scaling configuration does not imply that the required licenses are installed or not required. If a required license is not present, the system issues a warning message after it commits the configuration.

Software Feature Licenses

Each license is tied to one software feature pack or scaling level, and that license is valid for only one router. Table 9 on page 60 lists the software features, their current level of support, and the license name.

Table 9: JUNOS Software Feature Licenses

| Licensed Software Feature | Supported? | License Name |
|--------------------------------------|------------|---------------------------------------|
| Per-subscriber RADIUS accounting | Yes | JUNOS Subscriber Access Feature Pack |
| Per-subscriber RADIUS authentication | Yes | JUNOS Subscriber Access Feature Pack |
| Address pool assignment | Yes | JUNOS Subscriber Access Feature Pack |
| Change-of-Authorization (CoA) | Yes | JUNOS Service Management Feature Pack |
| Dynamic autosensed VLAN | No | JUNOS Subscriber Access Feature Pack |
| Dynamic and static IP | No | JUNOS Subscriber Access Feature Pack |

Table 9: JUNOS Software Feature Licenses *(continued)*

| Licensed Software Feature | Supported? | License Name |
|---|------------|--------------------------------|
| Subscriber Secure Policy | Yes | Subscriber Secure Policy |
| Subscriber scaling (1000; base license) | No | Dynamic/Static Subscriber Base |
| L2TP scaling (1000; base license) | No | L2TP Base |
| Mobile IP scaling (1000; base license) | No | Mobile IP Base |

License Key Components

To manage JUNOS licenses, you must understand the components of a license key. A license key consists of two parts:

- License ID—Alphanumeric string that uniquely identifies the license key. When a license is generated, it is given a license ID.
- License data—Block of binary data that defines and stores all license key objects.

For example, in the following typical license key, the string **li29183743** is the license ID, and the trailing block of data is the license data:

```
li29183743 4ky27y acasck 82fsj6 jzsn4q ix8i8d adj7kr
            8uq38t ix8i8d jzsn4q ix8i8d 4ky27y acasck
            82fsj6 ii8i7e adj7kr 8uq38t ks2923 a9382e
```

The license data defines the device ID for which the license is valid and the version of the license.

Before You Begin

Before you begin managing the JUNOS software licenses, complete the following tasks:

- Purchase the required licenses.
- Establish basic network connectivity with the router. For instructions on establishing basic connectivity, see the *Getting Started Guide* for your router.

Managing JUNOS Licenses

The following sections describe how to manage the JUNOS licenses with the CLI:

- Adding New Licenses on page 62
- Deleting a License on page 62
- Saving License Keys on page 62

Adding New Licenses

To add a new license key to the router with the CLI:

1. Enter operational mode in the CLI.
2. Enter one of the following CLI commands:
 - To add a license key from a file or URL, enter the following command, specifying the filename or the URL where the key is located:

```
user@host> request system license add filename | url
```

- To add a license key from the terminal, enter the following command:

```
user@host> request system license add terminal
```

3. When prompted, enter the license key, separating multiple license keys with a blank line.

If the license key you enter is invalid, an error appears in the CLI output when you press Ctrl + d to exit license entry mode.

4. Go on to “Verifying JUNOS License Management” on page 63.

Deleting a License

To delete a license key from the router with the CLI:

1. Enter operational mode in the CLI.
2. Enter the following command for each license, specifying the license ID. You can delete only one license at a time.

```
user@host> request system license delete license-id
```

3. Go on to “Verifying JUNOS License Management” on page 63.

Saving License Keys

To save the licenses installed on the router to a file using the CLI:

1. Enter operational mode in the CLI.
2. To save the installed license keys to a file or URL, enter the following command:

```
user@host> request system license save filename | url
```

For example, the following command saves the installed license keys to a file named `license.config`:

```
user@host> request system license save ftp://user@host/license.conf
```

3. Go on to “Verifying JUNOS License Management” on page 63.

Verifying JUNOS License Management

To verify JUNOS license management, perform the following tasks:

- Displaying Installed Licenses on page 63
- Displaying License Usage on page 64
- Displaying Installed License Keys on page 64

Displaying Installed Licenses

Purpose Verify that the expected licenses are installed and active on the router.

Action From the CLI, enter the `show system license` command.

Sample Output `user@router> show system license`

```
License usage:

```

| Feature name | Licenses used | Licenses installed | Licenses needed | Expiry |
|------------------|------------------|-----------------------|--------------------|-----------|
| subscriber-acct | 0 | 1 | 0 | permanent |
| subscriber-auth | 0 | 1 | 0 | permanent |
| subscriber-addr | 0 | 1 | 0 | permanent |
| subscriber-vlan | 0 | 1 | 0 | permanent |
| subscriber-ip | 0 | 1 | 0 | permanent |
| scale-subscriber | 0 | 1000 | 0 | permanent |
| scale-l2tp | 0 | 1000 | 0 | permanent |
| scale-mobile-ip | 0 | 1000 | 0 | permanent |

Licenses installed:

License identifier: E000185416

License version: 2

Features:

```
subscriber-acct - Per Subscriber Radius Accounting
permanent
subscriber-auth - Per Subscriber Radius Authentication
permanent
subscriber-addr - Address Pool Assignment
permanent
subscriber-vlan - Dynamic Auto-sensed Vlan
permanent
subscriber-ip   - Dynamic and Static IP
permanent
```

Meaning The output shows a list of the license usage and a list of the licenses installed on the router. Verify the following information:

- Each license is present. Licenses are listed in ascending alphanumeric order by license ID.
- The state of each license is **permanent**.



NOTE: A state of **invalid** indicates that the license key is not a valid license key. Either it was entered incorrectly or it is not valid for the specific device.

- The feature for each license is the expected feature. The features enabled are listed by license. An all-inclusive license has **All features** listed.
- All configured features have the required licenses installed. The **Licenses needed** column must show that no licenses are required.

Displaying License Usage

Purpose Verify that the licenses fully cover the feature configuration on the router.

Action From the CLI, enter the `show system license usage` command.

Sample Output

```
user@router> show system license usage
```

| | Licenses | Licenses | Licenses | Expiry |
|------------------|----------|-----------|----------|-----------|
| Feature name | used | installed | needed | |
| subscriber-addr | 1 | 0 | 1 | 29 days |
| scale-subscriber | 0 | 1000 | 0 | permanent |
| scale-l2tp | 0 | 1000 | 0 | permanent |
| scale-mobile-ip | 0 | 1000 | 0 | permanent |

Meaning The output shows any licenses installed on the router and how they are used. Verify the following information:

- Any configured licenses appear in the output. The output lists features in ascending alphabetical order by license name. The number of licenses appears in the third column. Verify that you have installed the appropriate number of licenses.
- The number of used licenses matches the number of configured features. If a licensed feature is configured, the feature is considered used. The sample output shows that the subscriber address pooling feature is configured.
- A license is installed on the router for each configured feature. For every feature configured that does not have a license, one license is needed.

For example, the sample output shows that the subscriber address feature is configured but that the license for the feature has not yet been installed. The license must be installed within the remaining grace period to be in compliance.

Displaying Installed License Keys

Purpose Verify the license keys installed on the router.

Action From the CLI, enter the `show system license keys` command.

Sample Output

```
user@router> show system license keys
```

```
G03000002223 aeaqea qkjhd ambrha 3tkqkc ayareb zicik6
nv6jck btlxao 2trfyq 65cdou r5tbbb xdarpq
qq53lu qcx4vm ydakcs t3yyh2 v5mq
```

```
G03000002224 aeaqea qkjhd ambrha 3tkqkc ayargb zicik6
nv6jck btlxao 2trfyq 65cdou r5tbof l4uon5
7rokz7 wgdocl r4q32p 2wu4zf zrxax
```

```
G03000002225 aeaqea qkjhd ambrha 3tkqkc ayarab zicik6
```

```
nv6jck btlxao 2trfyq 65cdou r5tbiu jr6ui2  
1mqgqj ouzq5a aiokdn 4tr4u2 wmcq
```

Meaning The output shows a list of the license keys installed on the router. Verify that each expected license key is present.

Part 4

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