Chapter 1

Juniper Networks Router Overview

Each Juniper Networks M-series and T-series routing platform is a complete routing system that supports a variety of high-speed interfaces (including SONET/SDH, Ethernet, and ATM) for large networks and network applications. Juniper Networks routers share common JUNOS software, features, and technology for compatibility across platforms.

Application-specific integrated circuits (ASICs) form a definitive part of the router design and enable the router to achieve data forwarding rates that match current fiber-optic capacity. All M-series routers use the Internet Processor II ASIC, which performs the route lookup function and several types of packet processing, such as filtering, policing, rate limiting, and sampling. The T-series platforms use the new T-series Internet Processor for route lookups and notification forwarding.

This chapter provides a general overview of Juniper Networks M-series and T-series routers and routing platforms:

Router Architecture

This section describes the following:

Router Architecture for M-series Routers and T-series Platforms

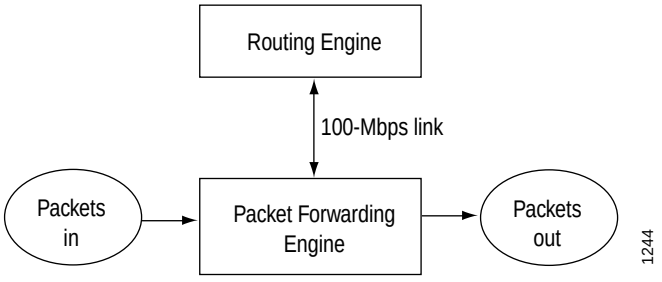
The router architecture of each Juniper Networks M-series router and T-series platform cleanly separates routing and control functions from packet forwarding operations, thereby eliminating bottlenecks and permitting the router to maintain a high level of performance. Each router consists of two major architectural components:

- The Routing Engine, which provides Layer 3 routing services and network management.
- The Packet Forwarding Engine, which provides all operations necessary for transit packet forwarding.

The Routing Engine and Packet Forwarding Engine perform their primary tasks independently, while constantly communicating through a high-speed internal link. This arrangement provides streamlined forwarding and routing control and the capability to run Internet-scale networks at high speeds.

Figure 1 illustrates the relationship between the Routing Engine and the Packet Forwarding Engine.

Figure 1: Router Architecture

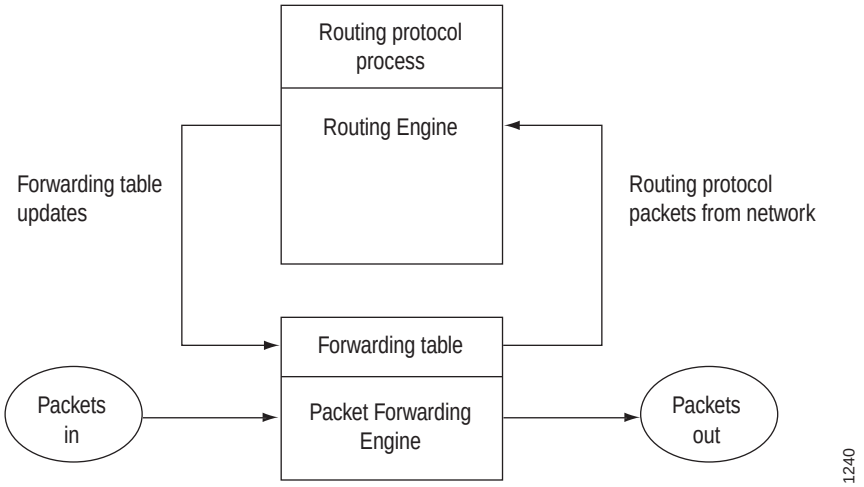


The Routing Engine consists of an Intel-based PCI platform running JUNOS software. For more information about JUNOS software, see “Cheat Sheet for the CLI Commands” on page 17 and “Command-Line Interface Overview” on page 321.

The Routing Engine constructs and maintains one or more routing tables. From the routing tables, the Routing Engine derives a table of active routes, called the forwarding table, which is then copied into the Packet Forwarding Engine.

The design of the Internet Processor II and T-series Internet Processor ASICs allows the forwarding table in the Packet Forwarding Engine to be updated without interrupting forwarding performance (see Figure 2).

Figure 2: Routing and Forwarding Table Updates



The Packet Forwarding Engine uses ASICs to perform Layer 2 and Layer 3 packet switching, route lookups, and packet forwarding. On M-series routers, the Packet Forwarding Engine includes the router midplane (on an M40 router, the backplane), Flexible PIC Concentrators (FPCs), Physical Interface Cards (PICs), and other components, unique to each router, that handle forwarding decisions.

The T-series platforms feature multiple Packet Forwarding Engines, up to a maximum of 16 for the T640 Internet routing node and 8 for the T320 Internet router. Each FPC has one or two Packet Forwarding Engines, each with its own memory buffer. Each Packet Forwarding Engine maintains a high-speed link to the Routing Engine. For information about T-series platforms, see the *T640 Internet Routing Node Hardware Guide* and the *T320 Internet Router Hardware Guide*.

Data Flow through the Packet Forwarding Engine

You can understand the function of the Packet Forwarding Engine by following the flow of a packet through the router: first into a PIC, then through the switching fabric, and finally out another PIC for transmission on a network link. Generally, the data flows through the Packet Forwarding Engine as follows:

1. Packets enter the router through incoming PIC interfaces, which contain controllers that perform media-specific processing.

2. The PICs pass the packets to the FPCs, where they are divided into cells and are distributed to the router's buffer memory.

3. The Packet Forwarding Engine performs route lookups, forwards the notification to the destination port, reassembles the cells into packets, and sends them to the destination port on the outgoing PIC.

4. The PIC performs encapsulation and other media-specific processing, and sends the packets out into the network.

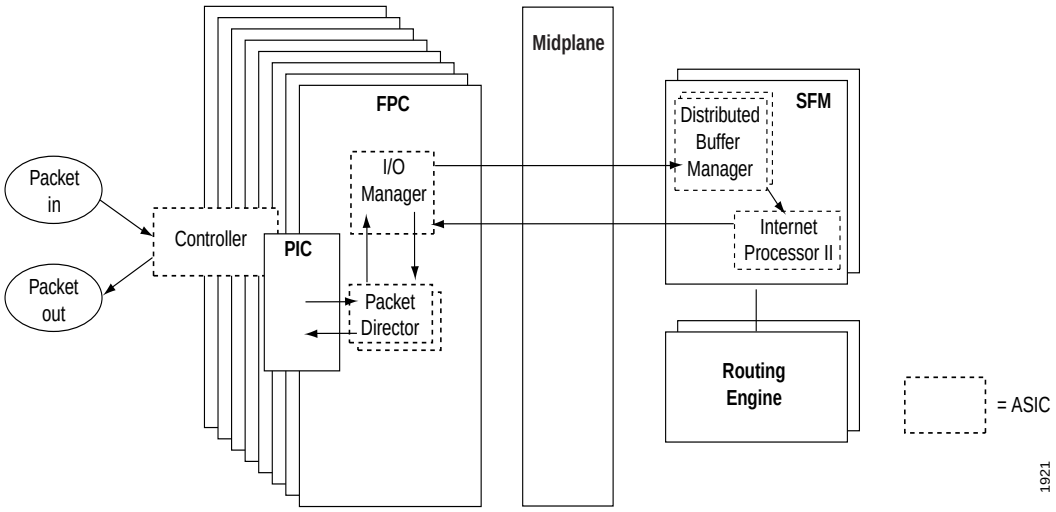
Data Flow through an M-series Router

Figure 3 illustrates the flow of data packets through an M-series router, using the M40e router architecture as an example. In this example, data flows in the following sequence:

1. A packet enters through the incoming PIC, which parses and de-encapsulates the packet, then passes it to the FPC.

2. On the FPC, the Packet Director ASIC distributes packets to the active I/O Manager ASICs, where each is divided into cells and sent across the midplane to the Switching and Forwarding Modules (SFMs). (On the M40e router, only one SFM is online at a time.) In addition, the behavior aggregate (BA) classifier determines the forwarding treatment for each packet.

Figure 3: Data Flow through an M40e Router



3. When cells arrive at an SFM, the Distributed Buffer Manager ASIC writes them into packet buffer memory, which is distributed evenly across the router's FPCs. The Distributed Buffer Manager ASIC also extracts information needed for route lookups and passes the information to the Internet Processor II ASIC.

4. The Internet Processor II ASIC performs the lookup in the full forwarding table, and finds the outgoing interface and specific next hop for each packet. In addition, the Internet Processor II ASIC performs filtering, policing, sampling and mulitfield classification, if configured.

5. The forwarding table forwards all unicast packets that do not have options and any multicast packets that have been previously cached. Packets with options are sent to the Routing Engine for resolution.

6. After the Internet Processor II has determined the next hop, it notifies a second Distributed Buffer Manager ASIC, which forwards the notification to the outgoing FPC. Queueing policy and rewrites occur at this time on the egress router. A pointer to the packet is queued at the outgoing port.

7. When the packet pointer reaches the front of the queue and is ready for transmission, the cells are read from packet buffer memory and are reassembled into the packet, which is passed to the outgoing PIC interface.

8. The PIC performs media-specific processing and sends the packet into the network.

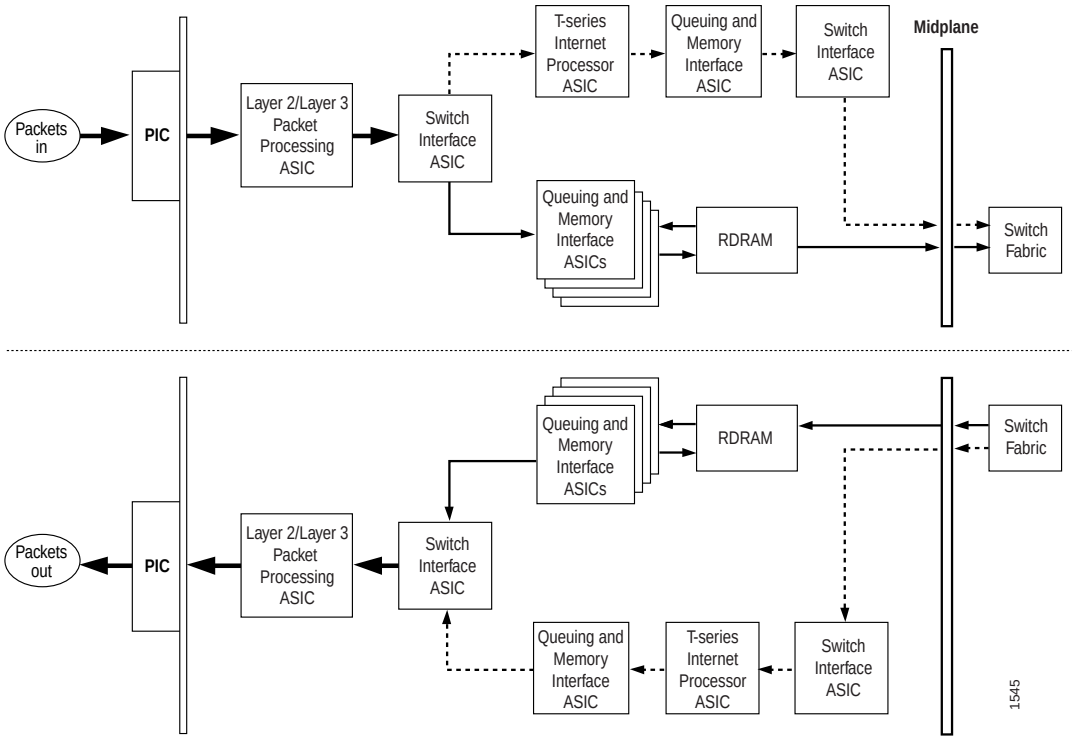
Data Flow through a T-series Routing Platform

Figure 4 illustrates the data flow through a T640 routing node. In this example, data flows in the following sequence:

1. Packets enter through an incoming PIC and are passed to the Packet Forwarding Engine on the originating FPC.

2. The Layer2/Layer 3 Packet Processing ASIC parses the packets and divides them into cells. In addition, the behavior aggregate (BA) classifier determines the forwarding treatment for each packet.

Figure 4: Data Flow through a T640 Routing Node



3. The network-facing Switch Fabric ASIC places the lookup key in a notification and passes it to the T-series Internet Processor.

4. The Switch Fabric ASIC also passes the data cells to the Queuing and Memory Interface ASICs for buffering on the FPC.

5. The T-series Internet Processor performs the route lookup and forwards the notification to the Queuing and Memory Interface ASIC. In addition, if configured filtering, policing, sampling and mulitfield classification, are performed at this time.

6. The Queuing and Memory Interface ASIC sends the notification to the switch-fabric-facing Switch Interface ASIC, which sends bandwidth requests through the switch fabric to the destination port, and issues read requests to the Queuing and Memory Interface ASIC to begin reading data cells out of memory.

7. The Switch Interface ASIC on the destination FPC sends bandwidth grants through the switch fabric to the originating Switch Interface ASIC.

8. Upon receipt of each grant, the originating Switch Interface ASIC sends a cell through the switch fabric to the the destination Packet Forwarding Engine.

9. On the destination Packet Forwarding Engine, the switch-fabric-facing Switch Interface ASIC receives the data cells, places the lookup key in a notification, and forwards the notification to the T-series Internet Processor.

10. The T-series Internet Processor performs the route lookup and forwards the notification to the Queuing and Memory Interface ASIC, which forwards it to the network-facing Switch Interface ASIC.

11. The Switch Interface ASIC sends requests to the Queuing and Memory Interface ASIC to read the data cells out of memory, and passes the cells to the Layer2/Layer 3 Packet Processing ASIC, which reassembles the cells into packets, performs the necessary Layer 2 encapsulation, and sends the packets to the outgoing PIC. Queueing policy and rewrites occur at this time on the egress router.

12. The PIC passes the packets into the network.

For more information about the M-series routers and T-series platforms, see the router platform-specific hardware guide, and the *JUNOS Hardware Network Operations Guide*.

Hardware Components

Each Juniper Networks router consists of a chassis and a set of components, including FPCs, PICs, Routing Engines, power supplies, cooling system, and cable management system. Many of the components are field-replaceable units. The following major components are discussed in this section:

Chassis

Chassis dimensions are listed in the physical specifications table for each router. For more information about chassis dimensions, see the router platform-specific hardware guide.

Each Juniper Networks router features a rigid sheet metal chassis that houses all of the router components. The chassis are designed to install into a variety of racks, including standard 19-inch equipment racks, telco center-mount racks, and four-post racks and cabinets. See Table 5 for the maximum number of each router type that can be installed into a rack. Each chassis includes mounting ears or support posts to facilitate rack mounting, and one or more points for connecting an electrostatic discharge (ESD) wrist strap for use when servicing the router.

Table 5: Maximum Number of Routers per Rack

Router or Routing Node	Maximum in Standard Rack
T640	2
T320	3
M160	2
M40e	2
M40	2
M20	5
M5 and M10	14

Each chassis includes a midplane (called the backplane on an M40 router). The midplane transfers data packets to and from the FPCs, distributes power to router components, and provides signal connectivity to the router components for system monitoring and control.

Flexible PIC Concentrators

The FPCs house the PICs used in the router and connect them to other router components. FPCs install into the front of the router in either a vertical or horizontal orientation, depending on the router. A compatible FPC can be installed into any available FPC slot, regardless of the PICs it contains. If a slot is not occupied by an FPC, a blank FPC panel must be installed to shield the empty slot and allow cooling air to circulate properly through the FPC card cage. Some routers support more than one type of FPC. Generally, the FPCs for each router are unique to that router; however, M20 and M40 FPCs are interchangeable, and the M40e and M160e type 1 FPCs are also interchangeable.

Physical Interface Cards

Juniper Networks M-series routers and T-series platforms use PICs to connect to a wide variety of network media. PICs receive incoming packets from the network and transmit outgoing packets to the network, performing framing and line-speed signaling for their specific media type. Before transmitting outgoing data packets, the PICs encapsulate the packets received from the FPCs. Each PIC is equipped with an ASIC that performs control functions specific to the PIC's media type.

See Table 6 for a list of current PIC interfaces.

Table 6: PIC Media Types

Media Type	Ports	Slots	Connectors	JUNOS Interface Name
ATM DS-3 ATM E3 ATM OC-3 ATM OC-12	4 4 2 1	Single Single Single Single	SC duplex	at
Channelized DS-3 Channelized E1 Channelized OC-12 Channelized STM-1 Multichannel DS-3	4 10 1 1 2	Single Single Single Single Single	Posilock to BNC RJ-48 SC duplex SC duplex Posilock to BNC	–
DS-3	4	Single	Posilock to BNC	t3
E1	4	Single	RJ-48 or BNC	e1
E3	4	Single	Posilock to BNC	e3
Fast Ethernet	4 8 12 48	Single Single Single Single	RJ-45	fe
Gigabit Ethernet 10-Gigabit Ethernet	1 2 4 4 1	Single Single Quad Single Quad	SC duplex SC duplex SC duplex SC duplex SC duplex	ge
ES Monitoring Services Multilink Services Tunnel Services	– – – –	Single Single Single Single	– – – –	es – ml gr or ip

Media Type	Ports	Slots	Connectors	JUNOS Interface Name
SONET/SDH OC-3c SONET/SDH OC-12c SONET/SDH OC-12c SONET/SDH OC-48c SONEC-SDH OC-48c SONET/SDH OC-48c SONET/SDH OC-48c SONET/SDH OC-192c SONET/SDH OC-192c	4 1 4 1 1 4 4 1 1	Single Single Single Quad Single Single Quad Quad Single	SC duplex LC duplex 	so
T1	4	Single	RJ-48	t1

PICs install into the FPCs (on the M5 and M10 routers, into the FEB). Each FPC can accept up to four PICs. The PICs for each router are unique to that router.

See Table 7 for the number and type of PICs that are currently supported on each router.

Table 7: PICs Supported on Each M-series Router

Supported PICs	M160	M40e	M20 and M40	M5 and M10
ATM DS-3 ATM E3 ATM OC-3 ATM OC-12	4 per FPC 4 per FPC 4 per FPC 4 per FPC	 4 per FPC 4 per FPC	4 per FPC 4 per FPC 4 per FPC 4 per FPC	M5–4, M10–8 M5–4, M10–8 M5–4, M10–8 M5–4, M10–8
Channelized DS-3 Channelized E1 Channelized OC-12 Channelized STM-1 Multichannel DS-3	4 per FPC 4 per FPC 4 per FPC 4 per FPC 4 per FPC	4 per FPC 4 per FPC 4 per FPC 4 per FPC	4 per FPC 4 per FPC 4 per FPC 4 per FPC 4 per FPC	M5–4, M10–8 M5–4, M10–8 M5–4, M10–8 M5–4, M10–8 M5–4, M10–8
DS-3	4 per FPC	4 per FPC	4 per FPC	M5–4, M10–8
E1	4 per FPC	4 per FPC	4 per FPC	M5–4, M10–8
E3	4 per FPC	4 per FPC	4 per FPC	M5–4, M10–8
Fast Ethernet	4 per FPC	4 per FPC	4 per FPC	M5–4, M10–8
Gigabit Ethernet 10-Gigabit Ethernet	4 per FPC 1 per FPC	4 per FPC	4 per FPC 1 per FPC	M5–4, M10–8 M5–1, M10–2
ES Monitoring Services Multilink Services Tunnel Services	4 per FPC 4 per FPC	4 per FPC 4 per FPC 4 per FPC	4 per FPC 4 per FPC 4 per FPC	M5–4, M10–8 M5–4, M10–8 M5–4, M10–8
SONET/SDH OC-3c SONET/SDH OC-12c SONET/SDH OC-48c SONET/SDH OC-192c	4 per FPC 4 per FPC 4 per FPC 1 per FPC	4 per FPC 4 per FPC 1 per FPC	4 per FPC 4 per FPC 1 per FPC	M5–4, M10–8 M5–4, M10–8 M5–1, M10–2
T1	4 per FPC	4 per FPC	4 per FPC	M5–4, M10–8

Table 8: PICs Supported on Each T-series Router

Supported PICs	T640	T320
Gigabit Ethernet	4 per FPC	2 per FPC
10-Gigabit Ethernet	4 per FPC	2 per FPC
ES		
Monitoring Services		
Multilink Services		
Tunnel Services	4 per FPC	2 per FPC
SONET/SDH OC-3c		
SONET/SDH OC-12c	4 per FPC	2 per FPC
SONET/SDH OC-48c	4 per FPC	2 per FPC
SONET/SDH OC-192c	4 per FPC	2 per FPC

Routing Engine

The Routing Engine consists of an Intel-based PCI platform running the JUNOS software. The Routing Engine maintains the routing tables used by the router in which it is installed and controls the routing protocols on the router. The T640 routing node, and the T320, M160, M40e, and M20 routers support up to two Routing Engines, while the M40, M10, and M5 routers support a single Routing Engine.

Each Routing Engine consists of a CPU; SDRAM for storage of the routing and forwarding tables and other processes; a compact flash disk for primary storage of software images, configuration files, and microcode; a hard disk for secondary storage; a PC card slot (on some M40 routers, a floppy disk) for storage of software upgrades; and interfaces for out-of-band management access.

Power Supplies

Each Juniper Networks M-series router and T-series platform has one, two, or four load-sharing power supplies. A single power supply can provide full power while the router is operational. The power supplies are redundant: if a power supply is removed or fails, the other power supplies automatically assume the electrical load. For more information about the redundant power supplies in each router, see “Power Supplies” in the router platform-specific hardware guide.

The power supplies are connected to the router midplane (on an M40 router, to the router backplane), which distributes the different output voltages throughout the router and its components. Some routers can operate using either AC and DC power; other routers operate with DC power only. For information about the type of power used by each router, see the “Electrical Specifications” table in the router platform-specific hardware guide.

Cooling System

Each Juniper Networks M-series router and T-series platform features a cooling system designed to keep all router components within recommended operating temperature limits. If one component of the cooling system fails or is removed, the system automatically adjusts the speed of the remaining components to keep the temperature within the acceptable range. The cooling system for each router is unique and can consist of fans, impellers, and air filters. For information about the cooling system components of each router, see the "Major Hardware Components" table in the router platform-specific hardware guide.

Monitor Hardware Components

NOTE: If the System Control Board (SCB), System and Switch Board (SSB), or Forwarding Engine Board (FEB) is not running, information about chassis components is not available through the command-line interface (CLI).

Action To use the CLI to monitor Juniper Networks routers, follow these steps:

1. Log in to the router. The CLI operational mode prompt (>) appears.

   If the operational mode prompt does not appear when you log in to the router, type **cli** to start the JUNOS software and enter operational mode. The prompt changes to >, indicating that you are in operational mode.

2. Use one of the operational mode CLI commands listed in Table 9 to monitor router hardware.

Table 9: Operational Mode CLI Commands for Router Monitoring

Command	Description
show version	Displays the router hostname, model number, and version of JUNOS software running on the router.
show chassis firmware	Displays the version of firmware running on the SCB, SFM, SSB, FEB, and FPCs.
show chassis hardware	Displays an inventory of the hardware components installed in the router, including the component name, version, part number, serial number, and a brief description.
show chassis environment	Displays environmental information about the router chassis, including the temperature and status.
show chassis environment *component-name*	Displays more detailed environmental information for the following router components: FPCs, Front Panel Module (FPM), Miscellaneous Subsystem (MCS), PFE Clock Generator (PCG), Power Entry Module (PEM) or power supply, control board, SONET clock generator (SCG), Switch Interface Board (SIB), Routing Engine, and SFM. This command works only on the M40e, M160, and T320 routers, and the T640 routing node.
show chassis craft-interface	Displays operational status information about the router, including the alarm status and LED status of major components.
show chassis alarms	Displays the current router component alarms that have been generated, including the date, time, severity level, and description.
show chassis *component-name*	Displays more detailed operational status information about the FPCs, Routing Engine, FEB, SCB, SFMs, and SSB router components, including the temperature of air passing by the Switch Plane Processor (SPP) card and the Switch Plane Router (SPR) card (the two SFM serial components), in degrees Centigrade. The command displays the total CPU DRAM and SRAM being used by the SFM processor. The command output displays the time that the SFM became active and how long the SFM has been up and running. A small uptime can indicate a problem.
show log messages	Displays the contents of the messages system log file that records messages generated by component operational events, including error messages generated by component failures. To monitor the messages file in real time, use the monitor start messages CLI command. This command displays the new entries in the file until you stop monitoring by using the monitor stop messages CLI command.

Command	Description
show log chassisd	Displays the contents of the chassis daemon (chassisd) log file that keeps track of the state of each chassis component To monitor the chassisd file in real time, use the monitor start chassisd CLI command. This command displays the new entries in the file until you stop monitoring by using the monitor stop chassisd CLI command.
request support information	Use this command when you contact the Juniper Networks Technical Assistance Center (JTAC) about your component problem. This command is the equivalent of using the following CLI commands (see "Contact JTAC" on page 15): ■ show version ■ show chassis firmware ■ show chassis hardware ■ show chassis environment ■ show interfaces extensive (for each configured interface) ■ show configuration (excluding any SECRET-DATA) ■ show system virtual-memory

Contact JTAC

If you cannot determine the cause of a problem or need additional assistance, contact JTAC at support@juniper.net or at 1-888-314-JTAC (within the United States) or 1-408-745-9500 (from outside the United States). For details on the information you need to provide for JTAC, See "Contact JTAC" on page 99. For steps to return a failed component, see "Return the Failed Component" on page 100.