

BUILDING HIGHLY AVAILABLE ENTERPRISE NETWORKS WITH EX SERIES ETHERNET SWITCHES

Carrier-Class Reliability for High-Performance Businesses

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Executive Summary

The enterprise network has long been a crucial component of business operations. However, current business and technology trends—from globalization to the convergence of data, voice and video—are making the network more critical than ever, driving the need for nonstop operations. IT faces a number of challenges in reducing both planned and unplanned network outages and the resulting service degradation, whether they result from upgrades, hardware failures, software failures, or human error.

Key to achieving five “9s” or 99.999 percent uptime is boosting device, network and operational availability. Juniper Networks® EX Series Ethernet Switches have all three aspects of availability designed in, giving enterprises the flexibility to implement high availability (HA) in all portions of the network.

At the device level, Juniper provides hot-swappable and redundant components and modular software for fault isolation, with nonstop software upgrades for platforms with redundant Routing Engines. To improve network-level availability, fixed-configuration Juniper Networks EX3200 Ethernet Switch, EX4200 Ethernet Switch and EX4500 Ethernet Switch with Virtual Chassis technology, and the modular EX8208 and EX8216 Ethernet switches with Virtual Chassis technology all enforce network access controls and support link, path and route redundancy. In addition, each switch platform comes standard with consistent control plane software that includes full Layer 3 support and robust quality-of-service (QoS) mechanisms to ensure stable network operations and consistent traffic handling end to end.

Recognizing that human error is the primary cause of network downtime, Juniper Networks has also focused on operational availability. By adhering to a strict software development and release process, Juniper greatly simplifies new feature deployment and software upgrades, reducing the likelihood of operator error. In addition, Juniper software offers tools that can automate routine configuration and management tasks, further reducing the chances of downtime triggered by a misconfiguration or poorly implemented change.

With its EX Series Ethernet Switches, Juniper is advancing the economics of networking, enabling customers to build the high-performance, carrier-class infrastructure they need for nonstop operations, while at the same time reducing both capital and operational expenses. This enables enterprises to invest more time and money on strategic projects and less on keeping the network up and running.

Introduction

The days when three or four “9s” was an acceptable level for LAN availability is a distant memory for many IT organizations. Enterprises have grown steadily more dependent on their networks for all aspects of operations, but several trends in particular are driving the need for a carrier-class network delivering at least five “9s” of uptime.

Globalization requires business processes to operate around the clock to support employees, partners and customers who might be anywhere in the world. When enterprise resource planning (ERP), supply chain management (SCM), customer relationship management (CRM), and other business tools must be available 24x7, so must the network that delivers these applications.

In addition to supporting a distributed workforce, data centers and facilities, enterprise networks must also support increasingly distributed applications. Service-oriented architectures (SOAs), which enable applications to exchange data and participate in business processes regardless of operating system or programming language, require a network that is always on. SOA is essentially a collection of services that communicate with each other. Without the network, applications and business processes would screech to a halt.

At the same time, the enterprise network has evolved from a data-only transport to a multiservice freeway carrying a mix of data, voice and video, as well as traffic from a myriad of what were once disparate networks such as security scanners and other building automation systems. With the adoption of IP telephony (IPT) in particular, IT has been challenged to deliver the same level of availability for the data network that users have come to expect from a traditional PBX system.

Numerous studies have documented the consequences of network downtime. Immediate and potentially significant loss of revenue is one. Damage to the company’s image is another. Productivity suffers when employees can’t access email, phones or critical business applications, and customers might look elsewhere for information or to purchase products and services.

Organizations of all sizes suffer when downtime or service degradation occurs. According to Forrester Research, determining how productivity losses, missed sales opportunities and compliance penalties impact businesses is fairly easy to do—the average reported cost of downtime due to these causes is almost \$350,000 per hour. Calculating the business impact that downtime has on intangibles such as customer retention, company reputation, productivity, and morale is much more difficult.¹

Juniper has engineered its EX Series Ethernet Switches to address the need for “always-on” networks. With fixed-configuration EX3200 switches and EX4200, EX4500 and EX8200 switches with Virtual Chassis technology, IT can build the appropriate level of resiliency and redundancy into each layer of the network—from access and aggregation switches to the data center and core. With the EX Series, Juniper is advancing the economics of HA networking, allowing enterprises to spend more time and money on strategic projects and less on keeping the network running.

High Availability Challenges

IT departments face numerous challenges in reducing network downtime, whether it is caused by an outright failure or a service degradation that renders applications unusable. The complexity of today’s networks is a major issue impeding HA. The variety of devices and traffic types on the network continues to grow as new technologies such as IP telephony, videoconferencing, wireless LAN access, and Web services are deployed.

Errors can occur as IT re-architects the network to support new technologies. Likewise, unforeseen interactions between networked systems can lead to failures the IT staff might never have been able to predict. IT also finds itself in a constant battle with hackers and malicious coders whose goal is to take down networks.

While some downtime such as planned maintenance is under IT’s control, the events that cause the most significant business disruptions are power and IT hardware and network failures, followed closely by flood and human error—accidental misconfigurations or unauthorized changes made to the network that are incorrect, mistimed or fail to follow the appropriate workflow procedures.

What IT needs is a highly available network infrastructure that not only minimizes hardware and software faults, but also mitigates the impact of human error and provides the necessary audit trail for IT to learn from these incidents.

The Three Aspects of Availability

How much resiliency is enough is a business decision. Clearly, IT wants those portions of the network that support the largest number of users and the most critical resources to be the most highly available. The loss of an access switch impacts a few dozen users, whereas the loss of a data center switch that supports email servers could impact the entire company.

Once IT has determined the availability requirements for each portion of its infrastructure, the network must be designed and products selected with three aspects of availability in mind:

1. Device availability
2. Network availability
3. Operational availability

Products that address these three areas can help IT minimize a wide range of failures and cut the mean time to repair (MTTR) in the event of an outage. Built from the ground up, EX Series Ethernet Switches increase availability across all dimensions—device, network and operational—and at each level of the infrastructure, from access to core.

For example, Juniper Networks EX3200 Ethernet Switch meets the enterprise’s need for an entry-level access platform and includes HA features not found in other stackable Ethernet switches on the market. These include modular uplinks that support online insertion and removal, as well as field-replaceable fans and power supplies.

Juniper Networks EX4200 Ethernet Switch with Virtual Chassis technology is a unique platform that combines the scalability and compact form factor of stackable switches with the HA characteristics and high port densities of traditional chassis-based switches. The EX4200 features a high-speed 128 gigabits-per-second (Gbps) backplane interconnect that allows up to 10 switch units to be interconnected as a “virtual” chassis that operates and is managed as a single, logical device. (For more information, read the Juniper white paper “Juniper Networks EX4200 Ethernet Switches Deliver True Chassis Functionality in a Stackable Form Factor”).

¹Forrester Research, Inc. – May 18, 2011 “State of Enterprise Disaster Recovery Preparedness, Q2 2011” by Rachel A. Dines

The EX4200 gives IT the flexibility to deploy redundant devices in locations such as the wiring closet where it might not have been economical before. At the same time, the EX4200 makes it operationally easier to deploy redundant devices in mission critical parts of the network such as data centers, where top-of-rack switch deployments are the most common.

Juniper Networks EX4500 line of switches provides up to 48 wire-speed 10GbE ports in a two rack-unit platform. With the addition of Virtual Chassis technology, the EX4500 targets high-density 10GbE top-of-rack deployments in the data center and in campus aggregation and core deployments. The EX4500 supports redundant cooling and redundant power supplies, and when deployed in a Virtual Chassis configuration, also provides redundant Routing Engines.

The modular EX8200 line of Ethernet switches has been optimized for HA, modularity and configuration flexibility, making these switches ideal for those areas of the network traditionally supported by chassis-based platforms, including the network core, aggregation layer and critical data center deployments. The EX8200 also supports Virtual Chassis technology, enabling the creation of a single, unified and highly resilient network fabric with no single point of failure.

With the EX Series family of Ethernet switches, enterprises can leverage HA capabilities at the device, network and operational levels to build an infrastructure that delivers five 9s of uptime.

Table 1. The Three Aspects of Designing High Availability into the Enterprise Network

DEVICE AVAILABILITY	NETWORK AVAILABILITY	OPERATIONAL AVAILABILITY
<ul style="list-style-type: none"> • Physical redundancy • Nonstop routing (NSR) and nonstop bridging (NSB) • Virtual Chassis technology • Nonstop software upgrades • Modular operating system software 	<ul style="list-style-type: none"> • Network access control • Redundant network devices • Path redundancy and resiliency • Routed network designs • Quality of service (QoS) 	<ul style="list-style-type: none"> • Open standards • Consistent software features • Automated operational tasks • Reduced complexity

Designing in Device Availability

Device availability encompasses those characteristics and configurations of a device that boost its uptime. The EX Series has both hardware and software features that contribute to device availability.

Physical Redundancy Within the Device

At the device level, redundant components such as power supplies, fan trays, control modules, interface cards, and switch fabrics can eliminate the most common causes of hardware failure. These physical components should be both field-replaceable and hot-swappable, and failover from the downed component to the backup component should be automatic and seamless in highly critical portions of the network. IT can reduce the MTTR for a failed device and boost availability in all areas of the network, even the wiring closet, by deploying network gear with hot-swappable components. And in remote offices or branch locations lacking any IT staff, field-replaceable components ensure a low MTTR by making it easy for knowledge workers to swap a failed component for a spare.

EX Series Ethernet Switches deliver device-level redundancy in the following ways:

- **EX4200 and EX4500**—Offering chassis-class redundancy, both the EX4200 and EX4500 feature internal redundant load-sharing power supplies and fan trays with redundant blowers. Both the power supplies and fan trays are hot-swappable. Each fan tray includes three fans, any two of which can provide sufficient cooling to ensure continuous switch operation.
- **EX8200**—A carrier-class modular switch designed for the network core, the EX8200 comes standard with redundant load-sharing internal power supplies, a fan tray with redundant fans, two Routing Engines, and redundant switch fabrics—all components that many vendors typically sell separately. All of these components are hot-swappable to maximize device availability. The GRES feature ensures that Layer 2 forwarding and Layer 3 routing control pass seamlessly from the master to the backup Routing Engine in the event of a failure.

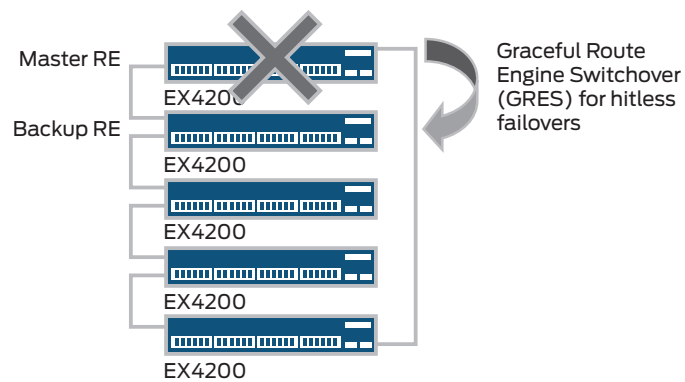


Figure 1: Graceful Routing Engine switchover helps maintain availability by ensuring a smooth and seamless transfer of control plane functions following a master Routing Engine failure.

Nonstop Routing and Nonstop Bridging

Nonstop bridging (NSB) and nonstop routing (NSR) mechanisms enhance the resiliency characteristics of network protocols by preventing service interruptions during the brief period when the backup Routing Engine takes over for a failed master Routing Engine. Left to their own devices, the absence of the master Routing Engine would cause routing and switching protocols to begin the process of reconverging network paths to route around what they determine to be a failed device. Juniper's NSR and NSB protocols prevent such a reconvergence from occurring, thus maintaining service continuity.

Future releases of the EX Series are expected to support NSR for protocols such as OSPFv2/3, RIPv1/2, RIPng, BGP, ISIS, and IGMPv1/2/3 on the Physical Interface Module (PIM) on EX4200 and EX4500 switches with Virtual Chassis technology, and on EX8200 switches in both standalone and Virtual Chassis configurations.

Likewise, future releases of the EX Series are expected to support NSB for protocols such as Spanning Tree Protocol (STP), Rapid Spanning Tree Protocol (RSTP), Multiple Spanning Tree Protocol (MSTP), VLAN Spanning Tree Protocol (VSTP), Link Aggregation Control Protocol (LACP), Link Layer Discovery Protocol (LLDP/LLDP-MED), 802.1X, MAC RADIUS, and captive portal on the same platforms listed previously.

Virtual Chassis Technology

Virtual Chassis technology allows IT to interconnect up to 10 EX4200 switches or two EX4500 switches as a single, logical device that provides chassis-class failover, management and expandability. Two EX4500 switches can also participate with up to eight EX4200 switches in a single Virtual Chassis configuration. Virtual Chassis technology makes it economically feasible for enterprises to deploy switches delivering device availability in areas where it previously might have been cost prohibitive or physically impossible. For example, the EX4200 and EX4500 can simplify connectivity and boost availability in the data center access layer, where IT prefers the space, power and costs of stackable switches but has deployed chassis switches to meet availability requirements.

Virtual Chassis technology is also available on the modular EX8200 switches, which provide a scaled solution for core and aggregation layers. EX8200-based Virtual Chassis configurations are highly resilient, with no single point of failure. The EX8200 implements Virtual Chassis with a redundant Juniper Networks XRE200 External Routing Engine (Figure 2). The Routing Engine externalizes the control plane, separating it from the data plane to deliver the most resilient design. Two EX8200 chassis can be interconnected to form a single Virtual Chassis configuration. The technology is expected to be extended to four chassis in the near term without the need to add additional XRE200 routing engines. The EX8200 with Virtual Chassis technology also supports NSR and NSB functionality.

The EX4200 and EX4500 switches were designed to support redundant Routing Engine functionality. Each switch in a Virtual Chassis configuration has a Routing Engine. When two EX4500 switches or two or more EX4200 switches are deployed in a Virtual Chassis configuration, they offer similar Routing Engine redundancy features as found in any Juniper chassis-based switch or router, including graceful Routing Engine switchover for hitless failover.

In a Virtual Chassis implementation consisting of two EX4500 switches or two or more EX4200 switches, Juniper Networks Junos® operating system selects one switch's Routing Engine to be the "master" and a second switch's Routing Engine as the backup in hot-standby mode. The remaining switches in the Virtual Chassis configuration serve as line cards only, ready to be selected as the backup Routing Engine if the master Routing Engine should fail. IT can selectively assign Routing Engines as master and backup, as well as determine the order in which the remaining switches ascend should the master and/or backup fail to ensure seamless and immediate failover.

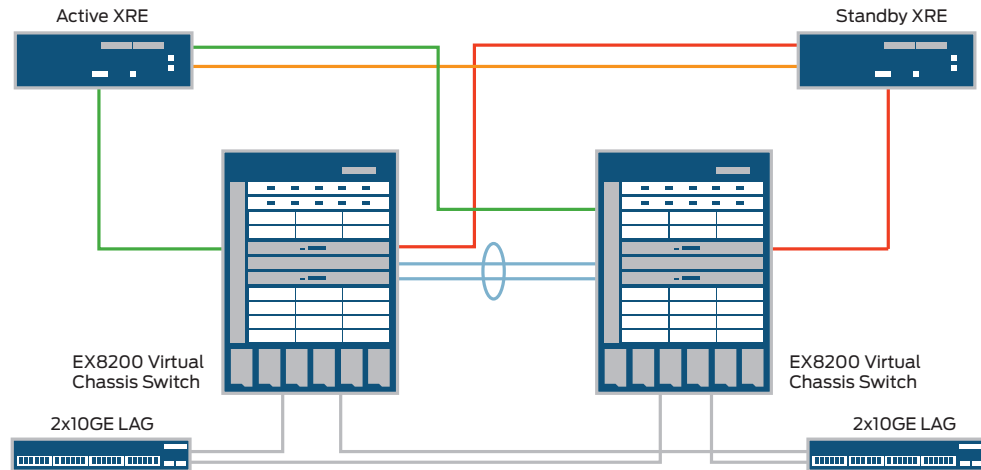


Figure 2: EX8200 Virtual Chassis configuration with XRE200 devices

Nonstop Software Upgrade

To make the always-on network possible and reduce planned downtime, IT must be able to perform software upgrades without taking a system down. Nonstop software upgrade (NSSU) enables IT to upgrade the software running on an EX8200 Ethernet switch with redundant Routing Engines or on an EX8200 Virtual Chassis configuration with redundant XRE200 Routing Engines using a single command and with minimal disruption to network traffic. NSSU is expected to be supported on the EX4200 and EX4500 switches with Virtual Chassis technology in a future release.

NSSU takes advantage of graceful Routing Engine switchover, NSR and NSB to ensure that there is no disruption to the control plane. By default, NSSU upgrades each line card one at a time, and traffic continues to flow through other line cards during this process. Traffic disruptions can be minimized by configuring link aggregation groups (LAGs) so that the member links of each LAG reside on different line cards. When one LAG member link is down, the remaining links are up and traffic continues to flow through the LAG.

Because upgrading each line card one at a time can increase the amount of time it takes to perform an upgrade, line cards can also be configured and upgraded simultaneously, in groups, which reduces the amount of time required to complete an upgrade.

As a first step in NSSU, the backup Routing Engine is rebooted with the new image and resynchronized with the master Routing Engine. Subsequently, line cards in the first upgrade group download the new image and reboot. Once they are online, the next group is upgraded. Once all groups are upgraded, the switch performs a graceful Routing Engine switchover. As a final step, the new image is installed on the original master Routing Engine.

In a Virtual Chassis configuration, the backup XRE200 is rebooted with the new image and resynchronized with the master XRE200. Subsequently, the master XRE200 installs the new image on the backup Routing Engines of the member switches. Each line card group in each member is then upgraded. Once all groups are upgraded, member switches perform a graceful Routing Engine switchover, followed by the master XRE200. As a final step, the new image is installed on the original internal and external master Routing Engine.

Modular Operating System Software

Networking devices have grown to offer rich functionality, which inherently increases reliance on software. Modularity is essential to stability because it provides functional separation of software components. A malfunction or bug in one module might cause the module to fail, while the rest of the system modules continue functioning. Likewise, if a problem is identified in a given module, it can be isolated, resolved and restarted gracefully without interruption. In contrast, a monolithic operating system has no such compartmentalization and a similar malfunction or bug is likely to cause a full system crash. Without modularity, the entire operating system would have to be changed and restarted, taking the switch out of service.

EX Series Ethernet Switches run Junos OS, a one-of-a-kind modular operating system that delivers consistent control plane features across the entire Juniper product line. The modular design of Junos OS provides protected areas in memory for the independent operation of each software module. Each protocol daemon runs in its own protected memory space so that a failure of one module does not disrupt any others. Junos OS automatically restarts a failed module without having to reboot the entire switch. Junos OS also features dedicated resources for routing, switching and packet forwarding that ensure predictable performance and stable device operation as new services are activated within a device.

Boosting Network Availability

Network availability encompasses those mechanisms and configurations that contribute to the availability of the network as a whole. The EX Series offers numerous features that contribute to maximum network availability.

Network Access Control

One way to increase network availability is to protect it from misuse. With access control, IT can strictly control who can access the network, preventing unauthorized users from logging on, for example, and ensuring that authorized users have the latest antivirus software and operating system patches installed on their systems.

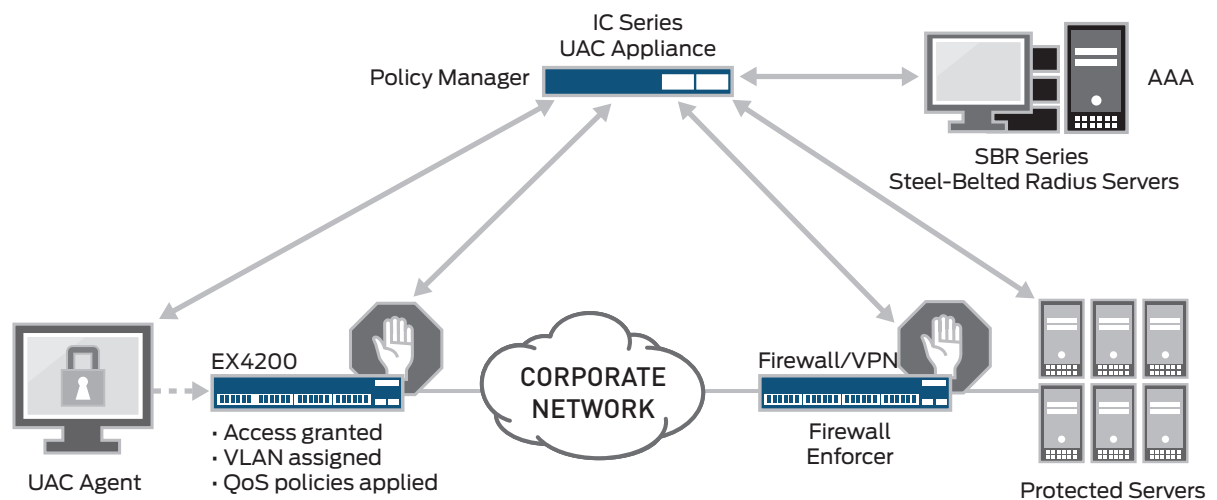


Figure 3: EX Series Ethernet Switches work with UAC to enforce access control down to the individual port level, improving availability by preventing network misuse.

For access control, the new Juniper switch platforms all support the industry standard 802.1X protocol and fully integrate with Juniper Networks Unified Access Control. Standards-based UAC provides port-level network access control with Layer 2-4 policy enforcement based on user identity. On the EX3200, EX4200, EX4500, and EX8200 lines of switches, every port acts as an enforcement point, permitting or denying network access and controlling traffic based on UAC policies.

Redundant Network Devices

In the most sensitive parts of the network such as the data center or core layer, IT should consider deploying fully redundant devices. For such configurations, EX Series switches support Virtual Router Redundancy Protocol (VRRP), which allows switches on the same subnet to seamlessly hand off routing functions. In the event of a fault, any backup switch automatically takes over for the primary switch in its “virtual router” group.

Path Redundancy and Resiliency

To increase network uptime, redundant connections are commonly used to link access switches to the aggregation layer, to interconnect core devices, and to link dual-homed servers to switches in the data center.

All EX Series Ethernet Switches support IEEE 802.3ad link aggregation as well as other mechanisms for ensuring path availability. On the fixed-configuration EX3200, EX4200 and EX4500 switches, for example, IT can use optional GbE or 10GbE uplinks to ensure highly available access deployments in wiring closets and data centers. On the EX4200 and EX4500, these uplinks can be distributed across any combination of switches that form a single virtual chassis, regardless of whether they're in separate wiring closets or at the top of separate server racks. In addition, IT can link aggregate (LAG) multiple GbE or 10GbE uplinks from any of the switches that form a virtual chassis configuration.

Along with the physical path redundancy, IT must consider which network protocols to rely on for fast failover or recovery in the event of a primary link failure. At Layer 2, Rapid Spanning Tree (802.1w) is preferable to the original STP, which can take 30 seconds or longer to ensure loop-free paths throughout the network when a backup link takes over. As an alternative to STP for access layer switches that are dual-homed to two distribution switches, the EX Series also offers the RTG feature, which provides a fast and simple failover mechanism without the complexity of STP.

Juniper Networks supports path resiliency through robust implementations of switching and routing protocols, including RTP, OSPF, BGP, and IS-IS. Standard Layer 3 protocols such as OSPF provide the fastest recovery from link failures and are more scalable than Layer 2 protocols. To improve further on Layer 3 protocol convergence times, Juniper supports Bidirectional Forwarding Detection (BFD) protocol, which provides rapid detection of link, interface, tunnel, and peer failures, resulting in continuous network operations.

Routed Network Design

IT should consider deploying a primarily routed network. While historically it made economic sense to use Layer 2 devices at the access layer, networks are less complex—and therefore more available—if a single, routed control plane operates from access layer uplinks to the aggregation and core layers. Such an architecture eliminates the need for STP, and with only Layer 3 to administer and troubleshoot, IT's job is simplified and human errors are reduced. In addition, a routed infrastructure supports more deterministic traffic flows.

Juniper Networks enables IT to use a single control plane by providing the same Layer 2 and Layer 3 functionality across all of its switch platforms. As part of the base license, each EX3200, EX4200, EX4500, and EX8200 switch comes standard with a full suite of Layer 2 and Layer 3 capabilities, including an application-specific integrated circuit (ASIC)-based packet forwarding engine—the EX-PFE—and a Routing Engine, as well as a complete set of Layer 3 protocols such as RIP v1/v2, OSPF and PIM-Sparse Mode. In contrast, other switch vendors require enterprises to purchase Layer 3 capabilities as an advanced feature software license. Including these rich Layer 3 protocols in the base software license not only increases network availability, it also advances the economics of networking by delivering more functionality without increasing capital expenses.

QoS Mechanisms

To prevent service degradation that renders applications unusable, IT needs to select LAN switches that can ensure consistent throughput and traffic control across the entire network. If just one switch is overwhelmed with traffic and begins randomly discarding packets, it can have a nasty ripple effect on service throughout the network.

Juniper has designed its new switch platforms with a consistent, granular set of QoS capabilities that provide predictable application performance across any combination of traffic types. All EX Series Ethernet Switches support eight class-of-service (CoS) queues on every port, as well as a common set of queuing, traffic shaping and congestion management algorithms. (For more information, read the Juniper Networks white paper “Juniper Networks EX Series Ethernet Switches: QoS-Enabling the Enterprise.”) With these QoS mechanisms, Juniper switches can prevent downtime due to service degradation and ensure that business-critical and latency-sensitive applications have the resources they need for optimal operation.

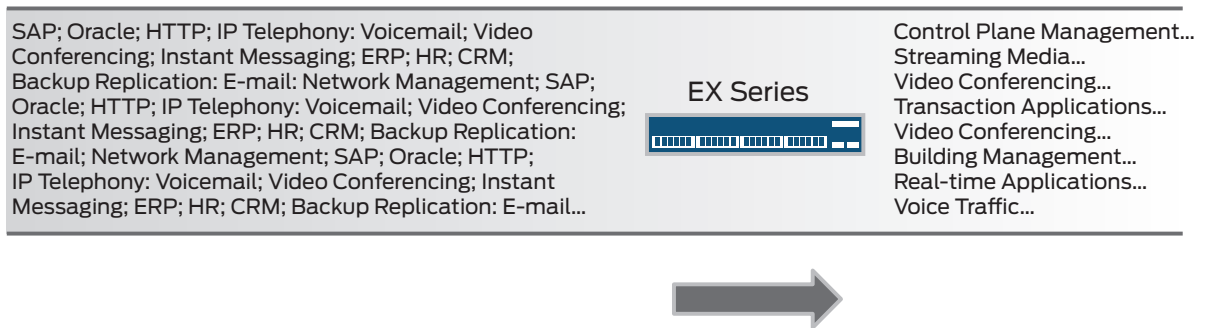


Figure 4: All EX Series switches provide eight queues per port, preventing downtime associated with service degradation.

Operational Availability—Simplifying Operations

Given that human error is the leading cause of network downtime, enterprises have the most to gain from operational availability, which equates to simplifying routine operations and maintenance. IT can simplify operations by selecting products with features, processes and tools that reduce complexity and automate tasks. Recognizing how critical human factors are to business continuity, Juniper has established a disciplined software release process that significantly reduces network complexity. It has also developed management tools that cut operational overhead.

Reduce Complexity

IT can reduce network complexity by using standards-based technologies and products. In addition, having the same software image across all Layer2/Layer 3 platforms makes it easier to roll out new features and new versions of software.

To this end, Juniper Networks implements a common set of industry-standard protocols on its switches and routers, including OSPF, IS-IS and STP. Support for standards reduces compatibility problems and boosts interoperability between different vendors' devices. By supporting the same standard technologies across all switch and router platforms, Juniper can ensure consistent and therefore more predictable network operations.

Juniper further reduces network complexity by delivering a single operating system—Junos OS—that follows a single release train and implements a common instance of control plane features across its entire product line. All Juniper switch and router platforms run the same Junos operating system. That means that OSPF on Juniper Networks T Series Core Routers, M Series Multiservice Edge Routers and J Series Services Routers, for example, is the same as on the EX3200, EX4200, EX4500, and EX8200 switches—ensuring consistent protocol configuration, management and behavior from the branch to the data center.

In addition, Juniper follows a disciplined development process to create a single base of Junos OS source code. The Junos operating system's modular architecture allows Juniper to add new features incrementally, without requiring a complete overhaul of the code. As a result, each new version of Junos OS is a superset of the previous version. New features can only be added to the software mainline—never to fix bugs in releases—ensuring stability from one revision to the next. In addition, Junos OS follows a rigid quarterly release schedule. When a new version is released, Juniper releases it for all product lines at the same time.

By running a consistent operating system and maintaining the discipline of a single release train, Juniper ensures a consistent feature set across all of its Junos OS-based products, as well as a consistent implementation and management of those features. This disciplined approach dramatically reduces configuration, operations and management overhead for IT as well as human errors. Not only is the learning curve for Junos OS substantially reduced as a result of its single implementation, but ongoing operations are also simplified. IT can configure and manage each feature the same way with the same effect throughout the network, and use the same tools to monitor, manage and update multiple devices.

Another benefit is interoperability. Having a single Junos OS implementation greatly simplifies new feature deployment, software upgrades and other network modifications. In contrast, when each Layer 2/Layer 3 platform runs a different software image, IT's ability to deploy a new feature is limited by the vendor's ability to implement that feature across diverse platforms. Incompatibilities can occur that lead to a cycle of patches and fixes. And when each platform runs a different OS or OS version, IT also has the challenge of learning platform-specific or version-specific operational details.

Operational simplicity infuses all of Juniper Networks' product designs. For example, because the switch elements in an EX4200 are linked via the virtual backplane, they operate as a single device with one control plane. Reachability information is shared automatically across interconnected devices. This eliminates the need for IT to instantiate location and reachability information in each switch, reducing the configuration burden and simplifying operations and management. With traditional stackable switches, each switch maintains its own control plane, including routing and bridging tables that IT must manage.

Automate Tasks

Manual entry of complex configuration commands is a prime source of errors. With the right tools, IT can automate many configuration and maintenance tasks and reduce downtime caused by human error.

Juniper streamlines operations by supporting the same management interface across all of its switch platforms and providing tools to automate common tasks. One such tool is Junos XML management protocol automation, a flexible scripting tool that allows IT to define customized configuration validation, troubleshooting and automated responses to specific situations.

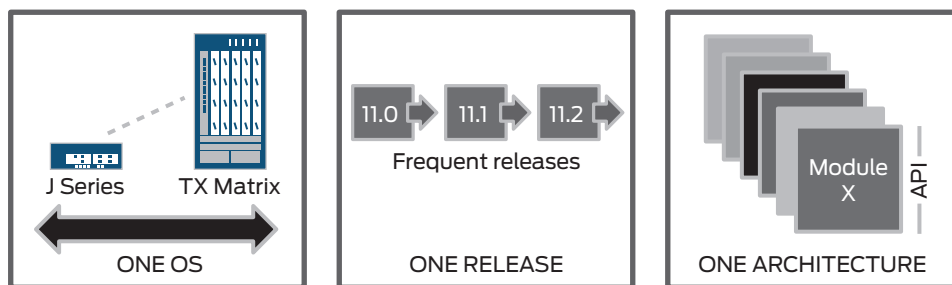


Figure 5: Junos OS utilizes a single source code, follows a predictable release train, and employs a single modular architecture.

For example, Junos OS offers commit scripts that help prevent operators from inadvertently bringing down the network due to configuration errors. As part of this process, Junos OS makes a copy of the running configuration. IT then makes changes to the copy or "candidate" configuration, not the live one. Automated checks within Junos OS verify the syntax and check for conflicts, informing operators of potential issues.

Junos OS also provides an optional confirmation step. When the confirm function is enabled, the administrator must approve the configuration changes within a defined time period or the system reverts to the previous configuration. This prevents unintended or incomplete configuration changes from negatively impacting operations, such as isolating remotely managed devices. Likewise, if a new configuration degrades operations, a rollback command quickly restores any of the 50 prior configurations. With the rollback feature, IT can rapidly restore a device—and therefore the network—to a known working state.

In addition to configuration validation, Junos XML management protocol automation can simplify operations and troubleshooting. Rather than wait for an event that's significant enough to trip alarms, Junos OS operation scripts allow administrators to automate early warning systems that not only detect emerging problems, but can also take immediate steps to restore normal operations, thus avoiding service degradation or outages. For example, if a script detects a potential problem such as high CPU usage or a dropped connection, it can take a range of actions—such as sending notification messages, checking other status indicators, or shutting down low priority processes. As each network outage gets diagnosed, IT can create a script to prevent a problem's recurrence or ensure that the next iteration has a shorter duration.

Conclusion—Juniper Networks' Switches Ensure Business Continuity

With the introduction of its EX Series, Juniper Networks is advancing the economics of networking, enabling customers to build the high-performance, highly available communication infrastructure they need for nonstop operations, while at the same time lowering capital and operational expenses.

Combining redundancy and resiliency features in a variety of form factors at competitive price points, Juniper's fixed-configuration EX3200 switches, EX4200 and EX4500 switches with Virtual Chassis technology, and EX8200 line of modular switches with Virtual Chassis technology give IT tremendous flexibility. These switch platforms make it possible for enterprises to build high availability into any—and potentially every—part of the network.

System continuity is at the heart of the Juniper engineering philosophy. Modular software, open interfaces, independent processes, and protected resources are some of the features that Juniper has explicitly designed into the Junos operating system from day one. In developing its new EX Series Ethernet Switches, one of Juniper's goals was to minimize hardware and software faults and to mitigate the impact of human error. By providing Junos OS and Layer 2/Layer 3 functionality across its full switch line—at no additional cost—Juniper is ensuring a consistent feature set. As a result, the enterprise benefits from predictable network behavior and improved uptime, while IT benefits from simplified operations.

About Juniper Networks

Juniper Networks is in the business of network innovation. From devices to data centers, from consumers to cloud providers, Juniper Networks delivers the software, silicon and systems that transform the experience and economics of networking. The company serves customers and partners worldwide. Additional information can be found at www.juniper.net.

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