WHITE PAPER

BUILDING A HIGHLY-AVAILABLE ENTERPRISE NETWORK WITH JUNIPER NETWORKS 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 non-stop 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® has designed its new EX Series Ethernet Switches with all three aspects of availability in mind, 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 in-service software upgrades available in a future Juniper Networks Junos® operating system release for those platforms with redundant Route Engines. To improve availability at the network level, Juniper Networks EX3200 Ethernet Switch, EX4200 Ethernet Switch with Virtual Chassis technology, and EX8200 line of Ethernet switches 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 focused on operational availability. By adhering to a strict software development and release process, Juniper greatly simplifies new feature deployment and software upgrades, as well as adds, moves and changes, 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 the introduction of its EX Series Ethernet Switches, Juniper Networks is advancing the economics of networking, enabling customers to build the high-performance, carrier-class infrastructure they need for non-stop 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 is a significant factor. Business processes need to operate around the clock to support employees, partners and customers who may 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. Services Oriented Architectures (SOAs), for example, which enable applications to exchange data and participate in business processes regardless of operating system or programming language, require an always-on network. 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 may look elsewhere for information or to purchase products and services.

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Organizations of all sizes suffer when downtime or service degradation occurs. According to Infonetics Research, for example, network downtime for a medium-sized business (those with 101 to 1,000 employees) costs a company an average one percent of its annual revenue, or $867,000[1]. For large enterprises, the costs can easily be triple that.

Juniper Networks has engineered its new EX Series Ethernet Switches to address the need for always-on networks. With Juniper Networks EX3200 fixed-configuration switches, EX4200 switches with Virtual Chassis technology, and EX8200 line of terabit-chassis switches, 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 Ethernet Switches, Juniper Networks is advancing the economics of high availability networking, allowing enterprises to spend more time and money on strategic projects and less keeping the network running.

High Availability Challenges

IT departments face numerous challenges in reducing network downtime, whether it's 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 continue 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 may 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, most network outages are the result of unexpected events such as configuration changes or human errors. In fact, research shows that accidental misconfigurations, unauthorized changes and similar operator errors are the most common causes of unplanned network downtime. According to Forrester Research, most network outages are the result of human error—changes made to the network that are incorrect, mistimed, or fail to follow the appropriate workflow procedures[2].

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

The Three Aspects of Availability

How much resiliency is enough is a business decision. Clearly, IT will want 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 will impact 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 the 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. Juniper Networks has designed its new EX Series Ethernet Switches to increase availability across all dimensions—device, network and operational availability—and at each level of the infrastructure, from access to core.

For example, Juniper Networks EX3200 Ethernet Switches meet 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.

The EX4200 Ethernet Switches with Virtual Chassis technology are unique platforms that combine 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 gigabit-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 Line of Switches Deliver True Chassis Functionality in a Stackable Form Factor.")

[1]Infonetics Research, "The Costs of Downtime: North American Medium Businesses 2006," March 2006

[2]"Forrester – Feb. 2007 "Who Has Changed My Network" by Evelyn Hubbert with Robert Whiteley and Rachel Batiancila

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The EX4200 gives IT the flexibility to deploy redundant devices in locations—such as the wiring closet—where it may 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 like data centers, where top-of-rack switch deployments are the most common. The Juniper Networks EX8200 line of terabit-chassis switches have been optimized for HA, modularity and configuration flexibility, making them ideal for those areas of the network traditionally supported by chassis-based platforms, including the network core, aggregation layer and critical data center deployments.

With the EX Series 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
• Redundant components	• Network access control	• Open standards
• Hot-swappable components	• Redundant devices and paths	• Consistent software features
• Modular operating system software	• Routed network designs	• Automate operational tasks
• In service software upgrades	• Quality of service	• Reduce complexity

Designing in Device Availability

Device availability encompasses those characteristics and configurations of a device that boost its uptime. The Juniper Networks EX Series Ethernet Switches have 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 as well as 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.

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

- EX3200: The EX3200 standalone platforms have a single internal power supply and fan, both of which are field-replaceable. For HA locations, IT has the option to configure the EX3200 with an external redundant power supply, which makes the internal power supply hot-swappable.
- EX4200: Offering chassis-class redundancy, the EX4200 features 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.

In addition, the EX4200 was designed to support redundant Route Engines. Each switch in a Virtual-Chassis configuration has a Route Engine. When two or more EX4200 switches are deployed using the Virtual Chassis technology, they offer the same Route Engine redundancy features as any Juniper chassis-based switch or router, including Graceful Route Engine Switchover (GRES) for hitless failover.

In a Virtual-Chassis implementation with two or more EX4200 switches, Junos OS selects one switch's Route Engine to be the "master" and a second switch's Route Engine as the backup in hot-standby mode. The remaining switches in the Virtual-Chassis serve as line cards only, ready to be selected as the backup Route Engine if the master Route Engine should fail. IT can selectively prioritize the Route Engines to assign master and backup status, as well as determine the order in which the remaining switches will ascend if the master and backup fail to ensure seamless and immediate failover.

- 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 Route Engines and redundant switch fabrics—all components that many vendors typically sell separately. All these components are hot-swappable to maximize device availability. The GRES feature ensures that Layer 2 forwarding and Layer 3 routing control passes seamlessly from the master to the backup Route Engine in the event of a failure.

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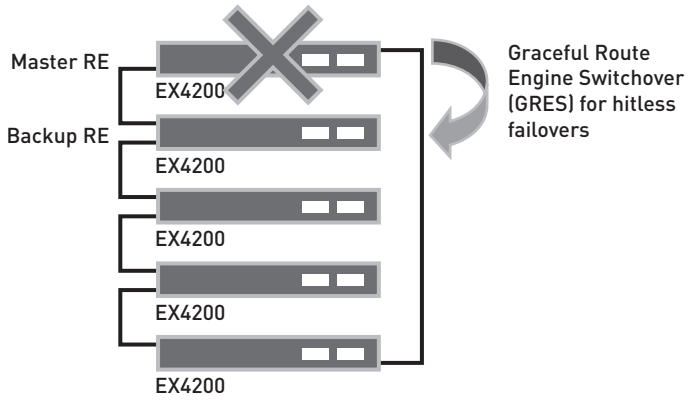

Figure 1: Graceful Route Engine Switchover (GRES) helps maintain availability by ensuring a smooth and seamless transfer of control planefunctions following a master Route Engine failure.

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.

The 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 will 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.

In-Service Software Upgrades

To make the always-on network possible and reduce planned downtime, IT must be able to perform software upgrades without taking a system down. While some chassis-based switches support in-service software upgrades, stackable switches must typically be updated individually—a time-consuming effort that involves taking each switch out of service for a period of time. Both the EX4200 switches with Virtual Chassis technology and EX8200 line of modular switches will support in-service software upgrades with a future release of Junos OS, enabling IT to deliver non-stop operations in more parts of the network.

Support for 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, the EX Series supports the 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 back-up switch will automatically take over for the primary switch in its "virtual router" group.

In addition, the EX4200 was designed with Virtual Chassis technology, which allows IT to connect up to 10 individual switches into a single logical system that provides chassis-class failover, management and expandability. The EX4200 makes it economically feasible for enterprises to deploy switches delivering device availability in areas where it may have been cost prohibitive or physically impossible before. For example, the EX4200 can simplify connectivity and boost availability in the data center access layer, where IT prefers the space, power and costs of stackable switches but have deployed chassis switches to meet availability requirements.

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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.

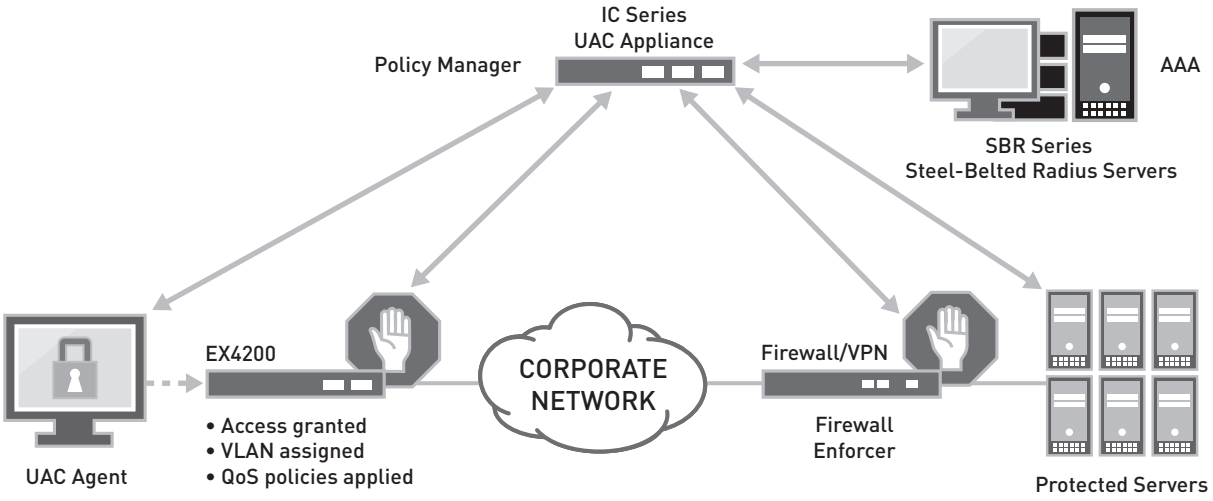

Figure 2: The EX Series Ethernet Switches work with UAC to enforce access control down to the individual port level, improving availability by preventing network misuse.

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

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 dual-home 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 EX3200 fixed-configuration and EX4200 switches, for example, IT can use optional Gigabit Ethernet or 10-Gigabit Ethernet uplinks to ensure highly available access deployments in wiring closets and data centers. On the EX4200, these uplinks may 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 Gigabit Ethernet or 10-Gigabit Ethernet 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 Spanning Tree Protocol (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 redundant trunk group (RTG) feature, which provides a fast and simple failover mechanism without the complexity of spanning tree.

Juniper Networks supports path resiliency through robust implementations of switching and routing protocols, including Rapid Spanning Tree, 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) which provides rapid detection of link, interface, tunnel and peer failures, resulting in continuous network operations.

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Non-stop bridging and routing mechanisms enhance the resiliency characteristics of network protocols by preventing service interruptions during the brief period when the backup Route Engine takes over for a failed Route Engine. Left to their own devices, the absence of the master Route Engine would cause routing and switching protocols to begin the process of reconverging network paths to route around what they believed to be a failed device. The Juniper Networks non-stop routing and non-stop bridging protocols prevent such a reconvergence from occurring, thus maintaining service continuity.

Single Control Plane

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 Spanning Tree; 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 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. (For more examples of how Juniper switches advance the economics of networking, read the Juniper Networks white paper "Advancing the Economics of Networking.")

Quality of Service (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.

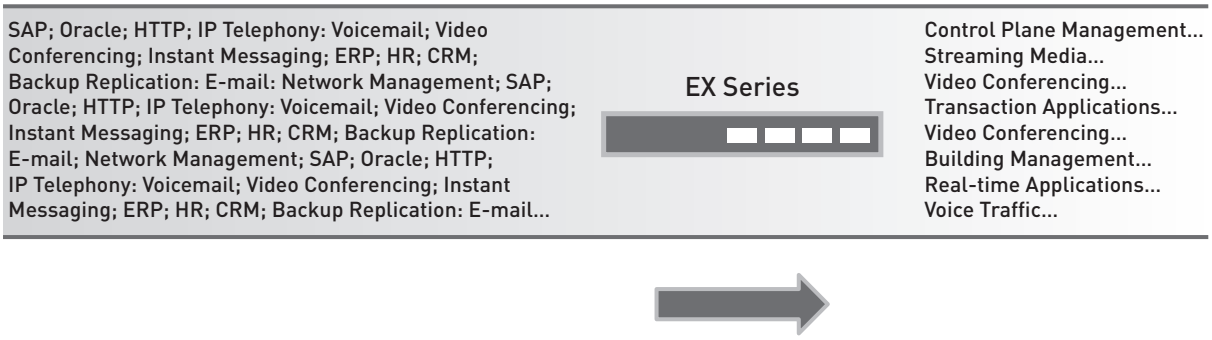

Figure 3: All EX Series Ethernet Switches provide eight queues per port, preventing downtime associated with service degradation.

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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 and 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 Spanning Tree. 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 Networks 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 OS; that means 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 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 OS' 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 bug-fix 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 Networks 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 will be 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- 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.

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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 Automation, a flexible scripting tool that allows IT to define customized configuration validation, troubleshooting and automated responses to specific situations.

Figure 4: 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 which 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 will revert to the previous configuration, preventing 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 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 Ethernet Switches, Juniper Networks is advancing the economics of networking, enabling customers to build the high-performance, highly available communication infrastructure they need for non-stop 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, the Juniper Networks EX3200 fixed-configuration switches, EX4200 with Virtual Chassis technology and EX8200 line of terabit-chassis switches 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 Juniper designed into the Junos OS 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.

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About Juniper Networks

Juniper Networks, Inc. is the leader in high-performance networking. Juniper offers a high-performance network infrastructure that creates a responsive and trusted environment for accelerating the deployment of services and applications over a single network. This fuels high-performance businesses. Additional information can be found at www.juniper.net.

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