

# JUNIPER NETWORKS SMART GRID NETWORKING SOLUTION

## Intelligent, Secure Solutions for Putting the “Smart” into the Smart Grid

### Challenge

The evolution from today’s energy grid to tomorrow’s Smart Grid is essential to more efficient distribution of energy resources, construction of environmentally friendly sources of electricity, faster response to unexpected energy needs, a more secure energy infrastructure, and informed consumer choices. The “smarts” of the Smart Grid is enabled by a next-generation information communications network that securely and reliably gives producers, distributors, and users the visibility into and control over the energy infrastructure.

### Solution

Juniper Networks best-of-breed network systems and extensive experience with high-performance, high-security, and next-generation networks provide a full Smart Grid information communications solution.

### Benefits

With Juniper Networks, energy and utility companies can realize:

- Pioneering IP/MPLS solutions for network consolidation and technology integration
- Providing a high-reliability, low-risk, low-maintenance OS
- Offering network systems that grow with the network, extending Return on Investment

Many national electric power infrastructures around the globe have been serving the needs of their populations for so long they are rapidly running up against their limitations. Economies are becoming increasingly dependent on electricity thereby driving growth in demand, shifts in newer renewable and distributed energy sources, demand management, regulatory policies and environmental considerations. What all of these challenges have in common is that they all require new, high-speed communications systems to make them a reality for the future.

To help meet these challenges utilities will require evolving diverse communications infrastructures to support improved collection, analysis, security and management of information, from generation, through transmission and distribution, all the way out to the end customer. The vision of Smart Grid is to provide this ability to utilize all forms of generation including renewables and monitor and manage power delivery with better reliability and efficiency, across an “Intelligent Utility Network (IUN)”.

The modernization of the nation’s energy distribution systems, collectively called the Grid, is a massive undertaking often compared in scale to the Apollo moon mission or the construction of the interstate highway system. Although the existing energy grid has been remarkably reliable, a number of factors are driving necessary changes:

- **Renewable Resources:** As ecological concerns over coal and nuclear power stations mount, clean energy sources are expected to supplement or even replace older electrical sources. The problem is that “green” power generation systems cannot always be built close to consumers. For example, solar power stations are usually built in deserts, wind farms on plains or in windy valleys, and tidal generators are necessarily along coastlines. The new distribution system must therefore carry power over longer distances to deliver electricity where it is needed.
- **Efficiency:** Wind, solar, geothermal, and tidal generation is more intermittent and less predictable than coal, natural gas, and nuclear powered plants. The new energy grid must be able to adjust to fluctuating energy supplies, using green sources when it can and traditional sources when necessary. On the consumer end, the grid must respond to varying demands caused by daily usage variations, changing weather, component outages, and even disasters. Increased system intelligence and visibility enables better management and distribution of available power and decreased reliance on spinning reserves. If the grid could be made just 5 percent more efficient the savings would be equivalent to permanently eliminating the fuel used and greenhouse gasses emitted by 53 million cars.
- **Security:** The national power grid is at the forefront of identified national security concerns. A successful cyber attack against its centralized control systems can cripple cities and slow or stop financial, communications, travel, security, and logistics systems nationwide. The information and control systems of the new energy grid must be better secured against outside threats while at the same time providing sharply increased public access for usage and analytic information.

- **Economic Stability:** The financial toll of even localized electrical outages can be high as financial transactions stop, traffic is snarled, retail sales are interrupted, factory and office workers are idled, and food spoils. A regional blackout can have devastating impact on the economy. According to a U.S. Department of Energy report, a one-hour outage at the Chicago Board of Trade in 2000 delayed \$20 trillion in trades and the economic losses caused by the Northeast blackout of 2003 totaled \$6 billion. Increased intelligence in the new grid will increase reliability and reduce the kinds of cascading failures that cause large-scale blackouts.
- **Real-Time Analytics:** Fast, efficient response to shifting power demands; the ability to accurately forecast peak usage and thereby bring reserve capacity online quickly but only when needed; responsiveness to outages caused by component failures, weather, or disasters; identification of and response to active security threats; immediate usage and billing information that helps consumers make well-informed choices; and automated information to smart appliances, smart homes, and smart buildings requires real-time visibility into the system for both humans and analytic data systems.

Table 1: Comparison of Today's Grid and the Smart Grid<sup>1</sup>

TODAY'S GRID	PRINCIPAL CHARACTERISTIC	SMART GRID
It responds to prevent further damage. The focus is on protection of assets following system faults.	Self-heals	It automatically detects and responds to actual and emerging transmission and distribution problems. The focus is on prevention. It minimizes consumer impact.
Consumers are uninformed and non-participative with the power system.	Motivates and includes the customer	Consumers are informed, involved, and active. There is broad penetration of demand response.
It is vulnerable to malicious acts of terror and natural disasters.	Resists attack	It is resilient to attack and natural disasters with rapid restoration capabilities.
It is focused on outages rather than power quality problems. There is slow response in resolving Power Quality (PQ) issues.	Provides power quality for 21st century needs	Quality of power meets industry standards and consumer needs. PQ issues are identified and resolved prior to manifestation. There are various levels of PQ at various prices.
There is a relatively small number of large generating plants. Numerous obstacles exist for interconnecting Distributed Energy Resources (DER).	Accommodates all generation and storage needs	Very large numbers of diverse distributed generation and storage devices are deployed to complement the large generating plants. There is "plug-and-play" convenience. There is significantly more focus on and access to renewables.
Limited wholesale markets are still working to find the best operating models. They are not well integrated with each other. Transmission congestion separates buyers and sellers.	Enables markets	Mature wholesale market operations are in place; well integrated nationwide and integrated with reliability coordinators. Retail markets are flourishing where appropriate. There is minimal transmission congestion and constraints.
Minimal integration of limited operational data with Asset Management processes and technologies. Siloed business processes. Time based maintenance.	Optimizes assets and operates efficiently	There is greatly expanded sensing and measurement of grid conditions. Grid technologies are deeply integrated with asset management processes to most effectively manage assets and costs. There is condition-based maintenance.

These factors are driving the development and deployment of Smart Grid technology—a decentralized system of sensors, controls, and applications interconnected by a standards-based digital network. Table 1 shows the U.S. Department of Energy's comparison of today's energy grid to the new Smart Grid.

Fundamental to the success of the Smart Grid is a high-quality digital infrastructure tying together all of the diverse intelligent components. Juniper Networks® is uniquely positioned to provide the right combination of high-performance hardware, carrier-class software, standards integration, and longstanding experience with network consolidation requisite to the Smart Grid.

<sup>1</sup> Source: United States Department of Energy, A Vision for the Modern Grid, July 2007.

## The Challenge

The comparison of the construction of the Smart Grid with the construction of the interstate highway system, or the Internet, is appropriate not only because of the huge project scope but also because the project has no identifiable end. It will be built over decades, and the advent of new technologies ensures its continuing evolution. But there are certainly identifiable challenges that must be met just to get the Smart Grid going.

## System Integration

The Smart Grid will not be built in isolation. Rather, it will begin by interconnecting the power generation stations, substations, control centers, and data centers of the existing grid across a shared information and communications network. Consumer sites from factories, office buildings, and hospitals to individual homes must be connected to the grid's information systems.

Legacy systems are based on many different data transport technologies such as ATM, Frame Relay, TDM, and Ethernet. The Smart Grid must accommodate these differing technologies while also providing a migration path to a common, shared technology that will reduce cost and complexity while sharply increasing security and reliability. The migration path moves legacy technologies from the core to the edge, and eventually out of the network entirely.

## Standards Integration

The information, control, and communications systems of today's grid use a variety of protocols—such as SCADA—that are designed for specific applications and are not interoperable. The Smart Grid must support transport of these specialized protocols while setting a goal of eventually replacing them with a single communications protocol shared by all components—from sensors and meters to data and control centers.

The communications protocol standard used by the Smart Grid must be not only interoperable but must also be proven, secure, and reliable. Such a unified standard reduces system complexity, thereby reducing both CAPEX and OPEX.

## Reliability

The intelligence infrastructure supporting the Smart Grid must have carrier-class reliability, generally defined as 99.999 percent or better uptime. Software design is every bit as important for achieving this level of reliability as redundant hardware and circuits. Component operating systems must be capable of limiting the scope of failures, and must be upgradeable without taking the system out of service.

Furthermore, the OS must provide features that prevent operator mistakes. Human error causes more network outages than either hardware or software failure—the more manageable and intuitive the OS, the more risk-free the network.

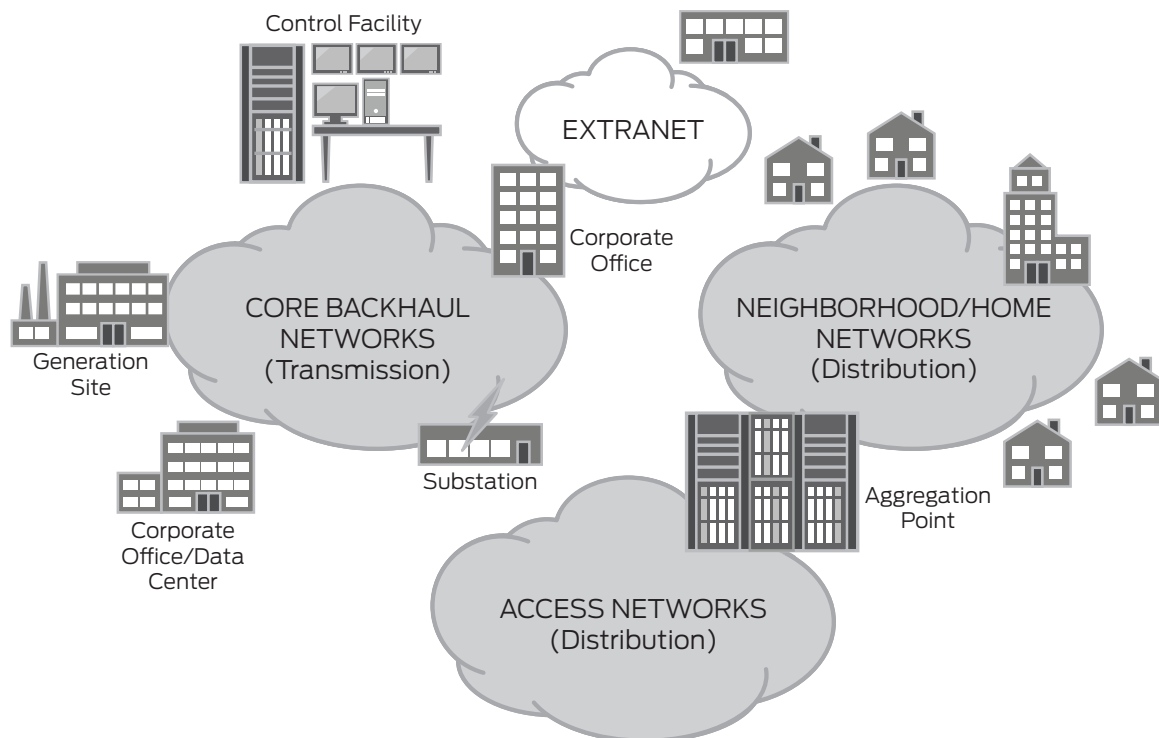


Figure 1: Today's grid consists of a mixture of mission-specific networks.

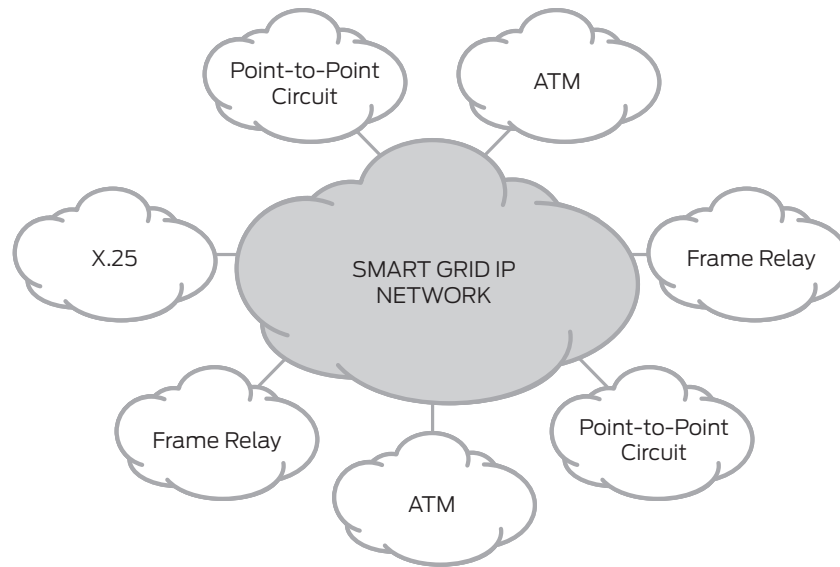


Figure 2: The Smart Grid information network must accommodate legacy systems while enabling new systems and new protocols.

### Security

Connecting consumers to energy information systems is an integral part of the Smart Grid. Yet providing public access can introduce enormous risks if the network is not tightly secured. Security extends from individual network components— which must be capable of protecting themselves—to the entire network, which must have the ability to restrict access at many different levels. Attack vectors must be identified, blocked, and traced to their sources. At the same time, the security capabilities of the network cannot impact the performance of the network.

### Economy

It makes little sense to build the Smart Grid information network with systems and components that themselves waste energy. By reducing the power consumption, cooling needs, and physical footprint of individual components the overall network will have a smaller environmental impact and will have sharply reduced operational costs.

### The Juniper Networks Smart Grid Solution

The Juniper Networks Smart Grid solution is built on an open standard, high-performance IP/MPLS core. This core is capable of connecting legacy systems while at the same time providing a common communications technology for future development. The solution is secure, flexible, resilient, and highly manageable.

### Features and Benefits

#### System Integration

MPLS is a mature, proven technology used as the core of almost all carrier networks and, increasingly, in many large enterprise networks. It is a generic tunneling protocol that can carry not only IP but also multiple Layer 3 address families and Layer 2 data link PDUs. As a result, MPLS is an ideal technology for interconnecting legacy networks such as ATM, Frame Relay, and switched Ethernet while simultaneously carrying IPv4 and IPv6 packets. Its multi-protocol or “protocol neutral” encapsulation makes MPLS the de facto standard for network consolidation.

MPLS is a virtual circuit technology like ATM or Frame Relay, but supported on routers rather than specialized Layer 2 switches. As a result it can be used to build multiple forwarding architectures over a single shared infrastructure, and can leverage the intelligence of the router control plane to add differentiated service qualities and engineered traffic behavior to the various architectures for meeting application requirements and building customer qualities of experience.

MPLS also enables the construction of virtual private circuits (VPNs) at both Layer 3 and Layer 2 to support strict network or service separation and security. Point-to-multipoint tunnels can be used as a simpler substitute for multicast routing, and virtual private LAN service (VPLS) can be built over MPLS to emulate an Ethernet switch spanning a metropolitan to regional to national footprint.

Juniper Networks pioneered the deployment of MPLS in highly demanding carrier and Telco networks, and its platforms appear in almost all large-scale, high-performance MPLS networks.

## Standards Integration

The modern data communication trend is “everything over IP.” From simple best-effort data to voice and video with stringent latency, sequencing, and jitter parameters, IP is the transport protocol of choice. The same MPLS core that can interconnect legacy communication networks can also interconnect IP, providing a simple and consistent migration path as more and more services are converted to IP. In the meantime, application-specific protocols such as SCADA can be tunneled over the MPLS core.

As the Smart Grid grows, millions or perhaps hundreds of millions of devices—such as sensors, meters, home appliances, HVAC and lighting systems, and plug-in cars—will be added to the information network interacting with data centers. Millions of power system controls and monitors will be connected to control centers over parts of the same information network. The advent of IPv6 opens a vast new pool of IP addresses with which to uniquely address each of these hundreds of millions of devices as they come online. And while the IPv6 address space is astronomically larger than that of IPv4, the new addresses are simpler to manage and easier to aggregate—reducing the demands on operations, management systems, and routing capacity.

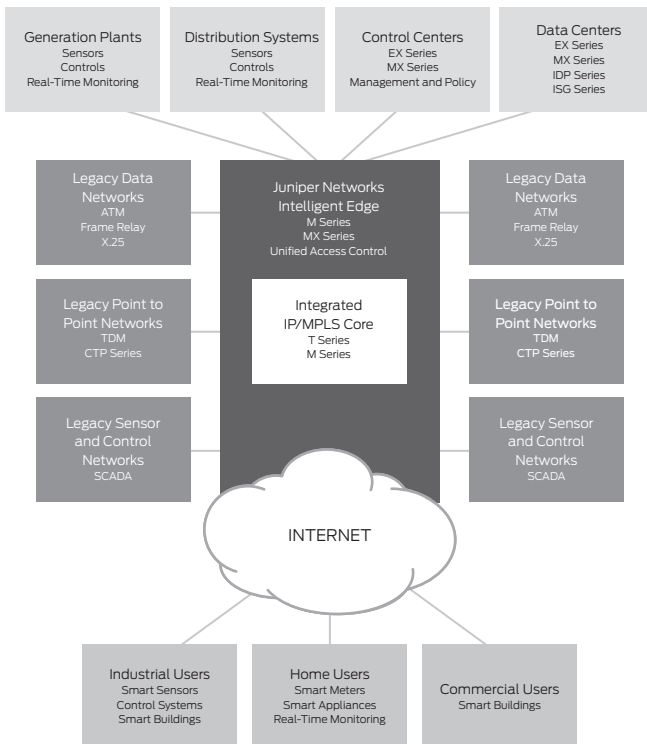


Figure 3: The Juniper Networks Smart Grid Solution integrates all aspects of the Smart Grid over a highly secure, high-performance IP/MPLS Infrastructure.

Juniper Networks has been an IP-focused company from its inception, and its engineers hold leadership positions in all of the well-known communications standards bodies. The company’s IP implementations have always been at the leading edge of development and will continue to be out front. At the same time, worldwide deployment in the world’s largest communications networks and most advanced research networks ensures that Juniper’s protocol implementations are thoroughly vetted under the most demanding conditions. Juniper’s equipment is low-risk because it could not survive in its market segments if the company were not.

## Reliability

The heart of the solution is the Juniper Networks Junos® operating system. Network reliability is increased through four key characteristics of Junos OS:

- Its modular architecture
- Its cross-platform, cross-feature consistency
- Features that reduce human error
- Features that reduce maintenance downtime

## JUNOS OS AND NETWORK INNOVATION

- Strong support for and leadership in open standards development are provided.
- All features in one package simplifies new feature implementations.
- Linear release train means simpler, faster feature rollout.
- Strict release schedule permits predictable new feature implementations.

The most essential architectural characteristic of Junos OS is its modularity. Rather than a single, highly complex code base, Junos OS consists of a set of individual components—each running in its own protected memory space, communicating with each other through well-defined interfaces, and all controlled by the Junos OS kernel. The separate modules are key to both stability and scalability.

Modularity is essential to stability because of the functional separation of software components. If a malfunction or bug in one module causes the module to fail, the rest of the system continues functioning. A monolithic OS, on the other hand, has no such compartmentalization and a similar malfunction or bug is likely to cause a full system crash. Similarly, because each module operates in its own protected memory space and cannot “scribble” on another module’s memory space, the modules cannot disrupt each other.

## JUNOS OS AND CAPEX REDUCTION

- Single release train for all T Series/M Series/J Series hardware: No hardware- or interface-specific images to buy
- No feature add-ons. All features are in one release package.

Stability is also supported by the ability to replace an individual module. So if a problem is identified in a given module, that module can be changed. Without modularity the entire OS would have to be changed, meaning the router must be taken out of service, to perform a similar code patch.

Cross-platform consistency means that the same Junos OS release can be run across the entire line of Juniper Networks routers and switches—there are no platform- or interface-specific releases from which to choose. Cross-feature consistency means that all features are available in the same Junos OS release—there is no complex matrix of choices to be consulted. This single release philosophy also contributes to reliability in that Juniper Networks engineers spend much less time regression testing new features across a complex set of releases, and therefore spend more time ensuring the code is right before it goes into customer networks. The end result is a dependable, carrier-grade operating system.

## JUNOS OS AND OPEX REDUCTION

- Operators spend less time maintaining the system.
- Operators spend less time upgrading the system.
- Linear release train means simple, predictable upgrades.
- A common operating system over multiple platforms means reduced training costs
- No separate feature sets means less time implementing new features

Anyone operating an IP network knows that the majority of network problems and outages come not from hardware or software failure, but from human error. Juniper Networks has, from its beginning, understood the human factor in network outages.

One of the many innovations of Junos OS was the inclusion of features for avoiding and recovering from operational mistakes during configuration changes—something no other router vendor offered. And while its competitors are still working to implement those most basic error-avoidance functions, Juniper Networks has continued to enhance Junos OS with innovative new features that reduce the risks of human error. For example, Junos OS include features that allow users to customize its configuration rules and behaviors to comply with their specific configuration and operations policies.

Finally, Junos OS improves network uptime by reducing the time a system must be out of service for routing maintenance and upgrades. A simple, linear release train is combined with features such as NSR and unified in-service software upgrades (ISSU) to make upgrade procedures fast, simple, and low-impact.

### Security

The routing and switching components of the Juniper Networks Smart Grid solution are tightly integrated with firewall, intrusion detection, network anomaly detection, access control, and unified network management components for best-in-class network security. The unified security solution enables fast attack detection and prevention with minimal performance penalties. Adaptive security policies can dynamically adjust to attacks in real time, and the network provides the tools for tracing attack attempts to entry points and documents the attempts for law enforcement response.

It is important to point out that many of the reliability features of the network are also security features. By preventing operator error and network outages, the risk of both malicious and non-malicious actions against the network is reduced.

### Economy

Juniper Networks systems combine industry-leading per-chassis and per-rack port densities with economical power and cooling requirements. Combined with strong virtualization capabilities, flexible and scalable Junos OS capabilities that allow adaption to future requirements in existing systems rather than purchasing new hardware and software, and innovative architecture design practices, Juniper Networks provides a “future-proof” network that reduces your total cost of ownership (TCO).

## Solution Components: Putting the “Smart” into Smart Grid

The heart of the Smart Grid is an information communications network tying together energy producers, distributors, and consumers. Producers can bring new environmentally friendly energy sources online; distributors can anticipate and quickly respond to shifting energy demands; and consumers have the real-time information for making smarter choices.

While introducing innovative new technologies, the Smart Grid must be capable of supporting existing systems and protocols to protect infrastructure investments and to control growth costs. National security demands the best network security features available, and real-time visibility into the network requires carrier-class reliability.

Juniper Networks is the recognized leader in meeting the demands of high-performance, large-scale, high-security networks worldwide. Juniper’s Smart Grid solution brings its expertise to bear to meet the demanding challenges energy producers and distributors face in making the Smart Grid a reality.

Table 2: Juniper Networks Solution Components

PRODUCT	DESCRIPTION
Juniper Networks EX Series Ethernet Switches	The EX Series Ethernet Switches represent a new era in networking. These highperformance carrier-class Ethernet switches are designed to meet the needs of today’s converged branch-office, campus, and data center networks.
Juniper Networks MX Series Ethernet Services Routers	The MX Series Ethernet Services Routers combine high performance with high-port density routing and switching functionality for large-scale data centers and core Ethernet switching.
Juniper Networks M Series Multiservice Edge Routers	The M Series Multiservice Edge Routers combine IP/MPLS capabilities with unmatched reliability, stability, security, and service richness. These multiservice edge routing platforms enable the consolidation of multiple networks into a single IP/MPLS infrastructure while simultaneously generating new revenues with leading edge services.
Juniper Networks T Series Core Routers	T Series Core Routers, which support the industry’s only 100 GbE router interface, are ideal for infrastructure that must scale to meet growing IP traffic. The T Series offers the lowest capacity-based power consumption in the industry.
Juniper Networks IDP Series Intrusion Detection and Prevention Appliances	The IDP Series provides protection against network- and application-level attacks before they damage the network, minimizing the costs associated with maintaining a secure network.
Juniper Networks Unified Access Control	UAC is a comprehensive network access control solution that combines user identity, device security state, and network location information to create unique, dynamic access control policy, per user and per session.
Juniper Networks ISG Series Integrated Security Gateways	These purpose-built, high-performance integrated security gateways are designed to deliver scalable network and application security for large enterprise, carrier, and data center networks.
Juniper Networks CTP Series Circuit to Packet Platforms	The CTP Series Circuit to Packet Platforms reliably transports time-division multiplexing (TDM) and other circuit-based applications across next-generation IP networks.
Management and Policy Platforms	Juniper Networks offers a wide range of software and hardware platforms for unified, flexible, dynamic control of security and routing policies, resource allocation, access control, and network insight across the entire line of Juniper Networks Smart Grid solution components.

## Next Steps

For more information about Juniper Networks Smart Grid Solution, please contact your Juniper Networks sales representative or visit [www.juniper.net](http://www.juniper.net).

## 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](http://www.juniper.net).

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