Q&A

Cisco CRS-1 Carrier Routing System Product and Technology

Q. What is the Cisco CRS-1?

A. The Cisco® CRS-1 Carrier Routing System is a routing platform with innovative hardware and software. The hardware includes the Cisco CRS-1 Line Card Chassis, switch fabric, route processors, and 40-Gbps interface modules. The system can be configured as both a single- and multishelf system. Also part of the Cisco CRS-1 portfolio is Cisco IOS® XR Software—a member of the Cisco IOS Software Family that takes advantage of a microkernel-based distributed operating system infrastructure to support the distributed processing capabilities of the Cisco CRS-1 that allow multishelf scaling of the platform.

Q. What is the latest addition to the Cisco CRS-1 family?

A. Cisco has just announced the availability of the Cisco CRS-1 4-Slot Single-Shelf System, a smaller form-factor Cisco CRS-1 chassis that is compatible with all current Cisco CRS-1 physical layer interface modules (PLIMs) and modular services cards (MSCs).

Q. What is the benefit of the Cisco CRS-1 4-Slot Single-Shelf System for service provider customers?

A. The Cisco CRS-1 4-Slot Single-Shelf System offers service provider customers the service flexibility and continuous system operation of the Cisco CRS-1 platform in a smaller and lower-cost configuration. Customers can now start with the new Cisco CRS-1 4-Slot Single-Shelf System and expand to the Cisco CRS-1 8-Slot Single-Shelf System, 16-Slot Single-Shelf System, or CRS-1 Multishelf System, making use of their investment across the multiple platforms. The Cisco CRS-1 4-Slot Single-Shelf System also supports the Cisco Interface Flexibility (I-Flex) design, which combines shared port adapters (SPAs) and SPA interface processors (SIPs), allowing customers to reuse SPAs on other Cisco service provider routing platforms such as the Cisco 7300, 7600, 12000, and XR 12000 Series Routers, helping customers take full advantage of their investments in these products.

Because of the continued support of innovative technology such as 40-Gbps OC-768 Packet over SONET (PoS), Cisco IP over Dense Wavelength-Division Multiplexing (IPoDWDM), secure virtualization, and scalable fabric-based multicast replication, and the high levels of support available in the Cisco IOS XR Software, customers can now deploy their high-speed core networks closer to regional and metropolitan centers as traffic between the two continues to increase with the proliferation of applications such as video on demand (VoD) and Cisco IP/TV® broadcasts.

Q. What are the typical applications for the Cisco CRS-1 4-Slot Single-Shelf System in service provider networks?

A. The Cisco CRS-1 4-Slot Single-Shelf System is typically used in smaller IP Multiprotocol Label Switching (IP/MPLS) core networks and for high-speed peering in smaller point-of-presence (POP) locations. The Cisco CRS-1 4-Slot Single-Shelf System can be used in small POP locations where space and power constraints may be factors. It can also be used as a regional aggregation router in cable deployments, as a core router in research and education networks, and in emerging-market deployments.

Q. What is the maximum capacity of a single Cisco CRS-1?

A. The Cisco CRS-1 is designed to scale to 92 Tbps—supporting up to 1152 40-Gbps line-card slots. Because of this scalability, customers can collapse multiple routers in existing architectures into a single Cisco CRS-1 system. Deployments of multishelf systems can give carriers multiterabit capacity in a single routing system while providing separate secure-domain-routing (SDR) instances for topology and management separation where needed.

A single-shelf system delivers 4, 8, or 16 40-Gbps line-card slots and can reach a switching capacity of 1.2 Tbps. System capacity can be increased without service interruption in 1.2-Tbps increments by adding shelves.

Depending on how service providers configure their networks, the Cisco CRS-1 can replace a significant number of routing nodes commonly found in service provider POPs, usually starting with the consolidation of routers from the core, peering, and aggregation tiers. Over time, consolidation of some routers from the edge tier can be achieved. Because of its scalability, availability, and flexibility, the Cisco CRS-1 is ideal for use in consolidated POP applications requiring future growth.

Q. What are the redundancy and resiliency features of the Cisco CRS-1?

A. The Cisco CRS-1 is built to serve as the foundation for next-generation network (NGN) infrastructure, in which greater than 99.999 percent availability—continuous system operation—is essential. The system achieves this level of availability through the extensive use of redundant and distributed components, including route processors, distributed route processors, power subsystems, and fan trays. Cisco IOS XR Software uses the Cisco CRS-1 architecture to advantage by distributing control- and management-plane processes to any available resource and moving these processes as necessary if any processor fails.

Q. What are the differences among the Cisco CRS-1 models?

A. Table 1 lists the Cisco CRS-1 systems available.

Table 1. Available Cisco CRS-1 Systems

Product Specification	Cisco CRS-1 4-Slot Single-Shelf System	Cisco CRS-1 8-Slot Single-Shelf System	Cisco CRS-1 16-Slot Single-Shelf System	Cisco CRS-1 Multishelf System
Slot capacity	4 slots	8 slots	16 slots	1152 slots
Aggregate switching capacity	320 Gbps	640 Gbps	1.2 Tbps	92 Tbps
Dimensions	H x W x D: 30 x 18.55 x 30.28 in. (76.2 x 47.12 x 76.91 cm) with front cover	H x W x D: 38.5 x 17.5 x 36.6 in. (99.06 x 44.45 x 93.0 cm)	H x W x D: 84 x 23.6 x 36 in. (213.36 x 59.94 x 91.44 cm)	–

Q. Is the Cisco CRS-1 targeted primarily at a specific geographical region?

A. The Cisco CRS-1 can be deployed globally and supports and complies with various regional safety and electromagnetic interference (EMI) standards. Furthermore, with its rich feature set and continuous system operation, customers in every carrier market segment and global region can benefit from its deployment. Current customers are deploying the Cisco CRS-1 in every region of the world and every market segment, including incumbent local exchange carrier (ILEC); interexchange carrier (IXC); post, telephone, and telegraph (PTT); Internet service provider (ISP); and cable segments.

Q. The Cisco IOS XR Software is newer than the Cisco IOS Software; will the current Cisco IOS Software become obsolete?

A. No. The Cisco IOS XR Software on the Cisco CRS-1 is built for multiterabit scaling and distributed operation. Cisco used its 20 years of expertise with its leading routing software to develop the Cisco IOS XR Software. The Cisco IOS XR Software is widely deployed in large production networks worldwide today, and Cisco continues on a regular basis to improve the Cisco IOS XR Software based on customer feedback.

Q. How many customers have deployed the Cisco CRS-1?

A. More than 50 customers worldwide have deployed or are in the process of deploying the Cisco CRS-1; more than 300 units have been shipped to date.

Q. Are the Cisco 12000 and XR 12000 Series Line Cards compatible with the Cisco CRS-1?

A. The fixed line cards are not compatible. The Cisco CRS-1 implemented a new design that extends the longevity of the system. Because the Cisco CRS-1 uses a midplane design, customers will benefit from being able to change interface modules (PoS/Dynamic Packet Transport [DPT], Ethernet, and so on) without having to replace the MSC—the packet-processing card for the Cisco CRS-1. Where customers have SPA-SIP combinations deployed on the Cisco 12000 and XR 12000 Series, the SPAs are interchangeable between the Cisco 12000 or XR 12000 Series and the Cisco CRS-1.

Q. Does the Cisco CRS-1 use a standard OC-768c PoS interface?

A. Yes.

Q. How is processing distributed within the Cisco CRS-1?

A. The microkernel internally processes only the essential services of the operating system, such as message passing, memory protection, and process or thread scheduling. All other elements, which are part of the kernel in traditional operating systems, such as the file system, network drivers, and process management, are implemented outside the kernel.

Processes such as routing and signaling protocols can run on a single route processor or be distributed over multiple route processors. Regardless of where these processes are performed and which memory pool they use, they operate as if they were running on the same route processor. This unique software distribution capability facilitates control-plane scalability so that no CPU or memory use can become a resource bottleneck.

This modern operating system architecture design allows the Cisco IOS XR Software to offer unprecedented availability and scalability as well as complete separation of the data, control, and management planes. The granular modularity helps ensure that only required processes are restarted upon process failure or during software upgrades, allowing in-service software upgrades (ISSUs). In addition, each process, such as Border Gateway Protocol (BGP), Intermediate System-to-Intermediate System (IS-IS) Protocol, and Open Shortest Path First (OSPF), is further segmented into individual threads and can be distributed to different processing resources.

ORDERING INFORMATION

Q. How do I order the Cisco CRS-1?

A. There are no changes to the ordering procedure. Use the same ordering tools that you use for other Cisco products, available at http://www.cisco.com/en/US/ordering/index.shtml.

Q. How do I verify the Cisco CRS-1 chassis configuration?

A. Use the dynamic configuration tool and enter the chassis part number at http://www.cisco.com/en/US/ordering/or13/or8/ordering_ordering_help_dynamic_configuration_tool_launch.html.

Q. What is the minimum software release that supports the Cisco CRS-1 4-Slot Single-Shelf System?

A. Cisco IOS XR Software Release 3.4 or higher supports the Cisco CRS-1 4-Slot Single-Shelf System.

Q. What is the service plan for the new Cisco CRS-1 4-Slot Single-Shelf System?

A. Cisco Technical Support Services have been extended to the Cisco CRS-1 4-Slot Single-Shelf System. These services are positioned to deliver solutions that meet customer needs today and support the transition to IP NGNs. Highlights include service pricing that accounts for features, functions, and software capabilities in a nonlinear approach and competitive service pricing based on total cost of ownership for multiyear engagements.

CISCO IOS XR SOFTWARE

Q. What is the Cisco IOS XR Software?

A. The Cisco IOS XR Software is part of the Cisco IOS Software Family. It is a distributed-processing operating system designed to meet the requirements for scalability, availability, and service flexibility that arise from the creation of converged IP NGNs for service providers that consolidate data, voice, and video services. It is specifically designed and optimized to operate on platforms that can scale and distribute processing as well as perform distributed forwarding, such as the Cisco CRS-1 and Cisco XR 12000 Series.

Q. What is the target market for the Cisco IOS XR Software?

A. Intended for use on the Cisco CRS-1 in IP/MPLS core network deployments, the Cisco IOS XR Software is optimized to meet the requirements of this audience—in particular, the massive scalability, continuous system availability, and exceptional service flexibility necessary as service providers begin to deploy NGN infrastructures.

Q. Is the Cisco IOS XR Software the next-generation replacement for the Cisco IOS Software?

A. No. The Cisco IOS XR Software is an addition to the Cisco IOS Software Family and is designed to support the unique distributed-processing and forwarding architectures of the Cisco CRS-1 and Cisco XR 12000 Series to meet the scalability, availability, and service flexibility requirements for IP NGNs. It is not a replacement for the other members of the Cisco IOS Software Family.

CISCO IOS XR SOFTWARE ARCHITECTURE

Q. What is the Cisco IOS XR Software operating system architecture?

A. Cisco IOS XR Software is built on a preemptive, memory-protected, multitasking, microkernel-based operating system architecture that provides the process and thread distribution necessary to take advantage of the distributed-processing, multiple-CPU architecture found in the Cisco CRS-1. In the Cisco IOS XR Software, features can be loaded and unloaded dynamically; processes reside in their own protected memory spaces, they can be restarted, and they communicate with each other through an advanced, reliable message-passing mechanism. Also, Cisco IOS XR Software implements a two-stage forwarding architecture in which forwarding decisions are made on both the ingress and egress line cards.

Q. How does the Cisco IOS XR Software differ from the Cisco IOS Software?

A. The Cisco IOS Software is a modular, cooperative, multitasking operating system in which processes operate in a shared memory space and feature sets are defined at system build time. It implements a single-stage forwarding architecture in which forwarding decisions are made on ingress ports or line cards. This architecture provides the appropriate performance and resource footprint for a broad set of platforms and markets.

Q. Can the Cisco IOS XR Software and Cisco IOS Software operate together in the same network?

A. Cisco has taken special care to preserve edge-to-edge interoperability in Cisco networks. This common heritage of Cisco IOS Software technologies preserves the Cisco end-to-end network capability that continues to be one of the major incentives for customers to choose Cisco as their single network vendor.

CISCO IOS XR SOFTWARE FEATURES

Q. Does Cisco IOS XR Software provide all the functions of Cisco IOS Software S-train releases?

A. Cisco IOS XR Software is designed to meet the requirements for scalability, availability, service flexibility, and manageability demanded by IP NGN infrastructures, and like Cisco IOS Software, its features and functions will continue to evolve over time; however, complete feature parity with Cisco IOS Software S-train releases is not currently an objective.

Q. Does Cisco IOS XR Software deliver MPLS VPN provider edge or multiservice edge functions?

A. Both Cisco IOS XR Software and the Cisco CRS-1 hardware architecture are built to provide long-term feature and service flexibility. Because the insertion point for the Cisco CRS-1 is core IP/MPLS networks and NGN infrastructures, emphasis has been placed on delivering core and peering features with excellent scalability, availability, and performance. Edge features and functions will be delivered in subsequent versions of Cisco IOS XR Software.

Q. I have heard that Cisco IOS XR Software includes software packaging and patchability. What are these features?

A. Unlike Cisco IOS Software T-train releases and many of the Cisco IOS Software S-train releases, in which the feature sets are defined at image build time and remain static while the system is in operation, Cisco IOS XR Software can dynamically load and unload software packages that can deliver one or many individual features. These software packages are created in versions and can be

updated individually or patched if necessary to add features or resolve problems, allowing system enhancement and maintenance to take place without requiring a system restart or disrupting traffic traversing the system.

Q. Does Cisco IOS XR Software offer any improvements in system management?

A. Cisco IOS XR Software provides numerous features designed to ease the management and monitoring of the Cisco CRS-1, which can scale to thousands of interfaces. These features include a series of embedded managers to provide onboard fault and event correlation; configuration management, including configuration versioning and rollbacks; an Extensible Markup Language (XML) management interface, and the Craft Web Interface that takes full advantage of XML to provide a standalone, GUI-based system management application.

Q. I have heard that Cisco IOS XR Software provides secure domain routers (SDRs); are SDRs the same as Virtual Route Forwarding (VRF) tables?

A. SDRs are much more than VRF tables; they allow a single Cisco CRS-1 to be partitioned into two or more distinct, individually managed routers that have their own routing identifiers and appear as routing peers to each other. This setup allows a single Cisco CRS-1 to function in multiple networks (such as a carrier's public and private IP infrastructures) or for a carrier to match its routing topology to its organizational structure by dividing a Cisco CRS-1 into core, aggregation, peering, and edge logical partitions.

Q. What is RPL?

A. RPL is an acronym for Routing Policy Language, which provides an alternative to route maps and offers a flexible, programmatic mechanism for managing routing policy.

Q. Does Cisco IOS XR Software use the same command-line interface (CLI) as Cisco IOS Software?

A. The Cisco IOS XR CLI is substantially similar to the Cisco IOS Software CLI, but it has additional commands and variations in command syntax and semantics where necessary to accommodate the unique operating system infrastructure and capabilities of the Cisco CRS-1.

MARKET EFFECT

Q. What networking function does the Cisco CRS-1 perform for service provider networks?

A. The Cisco CRS-1 was designed to provide carrier-class core IP/MPLS routing with enough scalability and reliability to allow service providers to begin the consolidation of their POP architectures, collapsing the traditional core, peering, aggregation, and edge routing tiers into just two layers—core and edge—and eliminating the need for costly redundancy as a means of achieving high availability.

Q. What barriers to growth and profitability do the major service providers face?

A. The primary barriers are inflexible service-specific networks and network complexity. The multiple service-specific network infrastructures that many service providers have deployed are too complex to scale and operate independently. Each requires its own operations staff, operating budget, and capital for maintenance and growth but offers little opportunity for growth through innovative new services. Voice networks offer voice; Frame Relay and ATM offer connectivity with restricted reach and bandwidth; and private IP and Internet infrastructures are separated. Service providers need one network, based on MPLS and IP, that can deliver any service, voice, video, or data, public or private, to any location, over any media. This network, an NGN, is the vision of many service providers, and it will be built on the foundation of NGN infrastructure.

Q. How can the Cisco CRS-1 help service providers become more profitable?

A. The Cisco CRS-1 helps service providers become more profitable by allowing them to reduce costs by consolidating their service offerings onto one simplified, scalable, highly available, and flexible infrastructure. Service providers can focus their capital and operations expenditures on one converged network instead of many and deliver innovative and profitable new services based on IP anywhere, over any media.

Q. How can the Cisco CRS-1 help service providers save money?

A. Service providers are expending enormous amounts of capital and resources by operating, maintaining, and scaling multiple service-specific networks. The Cisco CRS-1 allows service providers to begin pursuing their vision of a single, more efficient network for all services by offering them a routing system with the long-term scalability, continuous system availability, and service flexibility needed to build simplified NGN infrastructures.

Q. The Cisco CRS-1 delivers unprecedented scale and investment protection for a core router, but how can it help service providers deliver new and profitable services? What are some examples of these services?

A. The Cisco CRS-1 allows service providers to deliver profitable new services because it allows them to build IP/MPLS infrastructures with unprecedented scalability, availability, and flexibility. These IP/MPLS infrastructures can offer integrated voice, video, and data services anywhere that IP can reach. For example, traditional Frame Relay services are limited in bandwidth and reach, and they impose strict restrictions on network topologies. The equivalent IP/MPLS-based service—Layer 2 VPN—can be deployed over any media with no restrictions, allowing customers to build networks that match bandwidth to requirements, and it can use any available access service.

Q. What benefits does the Cisco CRS-1 bring to the customers of services providers: businesses and consumers?

A. Because the Cisco CRS-1 allows service providers to build highly scalable, available, and flexible NGN infrastructures, their customers have access to services that are highly integrated and flexible, with higher access speeds, faster provisioning, and wider service areas. In other words, they can buy any service, anywhere.

Q. Why are IP networks so important to service providers and what concerns with IP network deployments does the Cisco CRS-1 resolve for service providers?

A. IP networks are important to service providers because they offer them a means for delivering any service—voice, video, and data—anywhere the IP network reaches. The Cisco CRS-1 allows service providers to build IP networks that are simple, easy to operate, easily scaled, reliable, and flexible, creating benefits for both service providers and their customers.

Q. How does the Cisco CRS-1 fit in with service providers' existing circuit-switched networks?

A. The Cisco CRS-1 is a routing system that delivers the long-term scalability, high-availability, and exceptional service flexibility that service providers need to build NGN infrastructures—infrastructures that will allow them to transport traffic from circuit-switched networks and deliver equivalent services. Over time, service providers will be able to decrease their level of investment in service-specific circuit-switched network technologies and decommission these infrastructures when it makes sense to do so.

Q. Which specific carriers are currently using the Cisco CRS-1?

A. An up-to-date list of publicly announced customers is available at http://www.cisco.com/en/US/products/ps5763/products_press_coverage_list.html.

CISCO IPoDWDM SOLUTION

Q. What did Cisco announce on December 5, 2005?

A. Cisco announced further momentum in development of the network convergence layer of its IP NGN architecture with the introduction of the Cisco IPoDWDM solution on the Cisco CRS-1. The solution transparently converges the IP/MPLS and the DWDM (optical) layers to increase efficiencies, enhance reliability, and speed service deployment even as traffic growth occurs.

Two aspects of this solution are integrated to deliver a high-capacity, flexible intelligent core services architecture. First, the integrated DWDM transponders simplify the network by reducing the number of network elements and also scale at a lower total cost to decrease bandwidth costs. Second, Cisco provides the capability to dynamically activate wavelengths (optical bandwidth) without requiring multiple operations support systems (OSSs); activation can be performed using an integrated control plane based on generalized MPLS (GMPLS). A third feature, which is not a new announcement, is the interoperation of the Cisco CRS-1 integrated transponder

with the Cisco ONS 15454 Multiservice Transport Platform (MSTP), which is a reconfigurable optical add/drop multiplexer (ROADM). This interoperation is important, because ROADMs provide a much lower cost structure than do cross-connects at 10 and 40 Gbps. Now with the Cisco CRS-1, Cisco is delivering end-to-end Cisco IPoDWDM as one managed, integrated service platform.

This network convergence strategy features three critical integration points: element integration, control integration, and management integration.

- Element integration minimizes optical-electrical-optical conversions in the network to reduce the need for expensive standalone transponders and complex electrical switching equipment. In 2004, Cisco introduced OC-768c optical interfaces on the Cisco CRS-1, delivering 40-Gbps trunking for high-capacity terabit POPs and central offices; the company also launched its ROADMs, which integrate photonic switching into optical multiplexers. Building on its efforts to integrate IP and DWDM, Cisco is now introducing two new interfaces for the Cisco CRS-1 with integrated transponder functions, helping the Cisco CRS-1 originate fully tunable ITU grid-compatible colored wavelengths. The new interfaces feature two industry firsts:
  - A 1-port, 40-Gbps, tunable DWDM PoS interface that is designed to be compatible with existing 10-Gbps DWDM systems; this interface is the first tunable interface that provides a fourfold increase in throughput without requiring upgrades to existing DWDM infrastructures
  - A 4-port, 10-Gigabit Ethernet, tunable DWDM PHY interface with SONET/SDH-like operations, administration, maintenance, and provisioning (OAM&P); for the first time, providers can achieve 10-Gigabit Ethernet economics with carrier-class OAM&P and full compatibility with existing SONET/SDH OSS systems.

Both interfaces support enhanced, integrated forward error correction (FEC), providing up to a fivefold increase in reach and 50 percent reduction in optics. The interfaces are fully compatible with the Cisco ONS 15454 MSTP and are also designed to interoperate with any existing installed DWDM infrastructure.

- Control integration allows providers to migrate from today's manual provisioning process to a dynamic service-activation provisioning process. Building on the success of Cisco ROADM platforms, which facilitate the remote provisioning of optical wavelengths without requiring a complete equipment upgrade, Cisco announced the segmentation model of GMPLS (S-GMPLS) available on the Cisco CRS-1. For the first time, S-GMPLS takes advantage of the power of GMPLS IP control protocols for autoconfiguration of wavelengths while keeping the topology of the routing domain isolated from the topology of the DWDM domains, providing a way to deploy GMPLS while respecting organizational boundaries.
- Management integration provides flexible operating models designed to allow separate management of the IP and the DWDM equipment by different operating groups and, alternatively, to allow providers to deploy a unified management model to achieve operational cost efficiencies and reduce the time to service. The Cisco CRS-1 supports integration with third-party interfaces through XML and the Simple Network Management Protocol (SNMP).

Q. Why should the core remain optical?

A. A typical core POP has two major suites of equipment: optical and routing. In the optical domain, many of the wavelengths are transient or "pass-through," whereas the wavelengths that need to be dropped or inserted at the POP are terminated into a core router, where the wavelength is "converted" to IP/MPLS packets or labels. With all traffic moving to IP and growing quickly, these links being terminated and originated on the core router are typically well-used 10-Gbps links that do not require any grooming. In other words, one of the main value-adds of cross-connects-grooming-has suddenly disappeared because routers are performing this function. So, what is the value of converting every 10-Gbps lambda from optical to electrical to optical in these cross-connects? The only other reason then for a cross-connect would be to perform 10-Gbps add, drop, or reconfiguration, and this process can now be done by the ROADM in the optical domain. Therefore, staying in the optical domain, you can:

- Eliminate all optical-to-electrical conversions except inside the router

- Dramatically reduce the amount of optics and electrical switching infrastructure at each node, reducing CapEx and OpEx
- Reduce the complexity of numerous optical-to-electrical conversions and therefore increase reliability
- Future-proof the network because an all-optical approach is much more flexible in terms of accepting new protocols

Q. What happens if an operator needs to change the lambda to another color in an all-optical scenario?

A. That scenario is becoming less and less common, but it does still occur because of traditional designs. The use of ROADMs and an all-optical approach can cause a small amount of stranded bandwidth because colors cannot be changed in the ROADM. However, the significant CapEx and OpEx savings, increased reliability, and improved speed to service more than compensate for this stranded bandwidth.

Q. Does this solution require an upgrade of amplifiers or other DWDM infrastructure?

A. No. Both the 10-Gigabit Ethernet and 40-Gbps tunable DWDM interfaces work with existing 10-Gbps DWDM infrastructures. No upgrades are required.

Q. How do providers with an installed DWDM system deploy this solution?

A. Cisco tunable interfaces comply with ITU standards, so the wavelengths emitted by the Cisco CRS-1 meet the requirements for any DWDM multiplexing or demultiplexing equipment.

Q. How do providers with an installed SONET/SDH system deploy this solution?

A. Assuming that these providers are transporting some sort of SONET over 10-Gbps DWDM, operators can take a cap-and-grow approach, where they cap further investment in short-reach optics on the Cisco CRS-1 and SONET interfaces and transponders. They can deploy tunable DWDM interfaces on the Cisco CRS-1 and feed these directly into the optical multiplexing, demultiplexing, optical add/drop multiplexer (OADM), or ROADM equipment. Over time, if the operators choose, they can remove the SONET equipment to completely eliminate this layer in the core.

Q. Why does Cisco think that service providers will invest in the optical core now?

A. Providers have not invested much in new capacity over the last 4 to 5 years-a situation that, given a dramatic increase in IP traffic growth due to video and rich-media services, prompts additional buildout now.

Q. Does Cisco have 10-Gigabit Ethernet WAN PHY for networks with 10-Gbps SONET/SDH transport?

A. Cisco offers 10-Gigabit Ethernet LAN PHY. If operators decide not to proceed with the cost savings afforded by tunable interfaces, then they are actually more likely to deploy short-reach 10-Gigabit Ethernet LANPHY because they can purchase a 10-Gigabit Ethernet LANPHY interface—but not a 10-Gigabit Ethernet WAN PHY interface—on most SONET/SDH equipment.

Q. Does the Cisco IPoDWDM solution interoperate with products of any other vendors?

A. Cisco has products that interoperate with like products of three leading optical vendors, but the company is not free to disclose their names at this point.

Q. Is the Cisco IPoDWDM solution available on the Cisco 7600 Series?

A. Yes, pluggable XENPAK ITU grid-compatible optics are available on the Cisco 7600 Series. These optics work with both the Cisco ONS 15454 MSTP and third-party DWDM equipment.

Q. How does Cisco deliver SONET/SDH-like OAM&P with the 10-Gigabit Ethernet transport?

A. Cisco takes advantage of a framing standard called G.709, an ITU DWDM standard for framing 10-Gbps wavelengths with SONET/SDH-like framing for long-haul transport. This standard allows Cisco to use standard SONET/SDH alarms such as severely errored seconds (SER) and allows the carrier to use existing OSS alarm methodology.

Q. If I do not have SONET, how do I protect core IP traffic?

A. This is one of the crucial points of the Cisco strategy. All traffic is migrating to IP, and MPLS fast reroute has been optimized for <100-ms protection of IP traffic. So SONET protection at Layer 2 is not needed if there is an equally good protection scheme at Layer 3.

Q. How do I get 40 Gbps from existing 10-Gbps DWDM equipment?

A. Cisco uses a special modulation that increases the bit density per second without increasing the clocking scheme.

Q. How is resiliency improved?

A. Now that transponder functions are included in the router, the router control plane has visibility into all DWDM alarms. For example, the router can monitor FEC by measuring the number of errors corrected, and when signal degradation passes a predefined threshold, the router can take preventive action and trigger fast reroute before a problem occurs.

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