ANDY LACKOW

Intelligent LIGHT

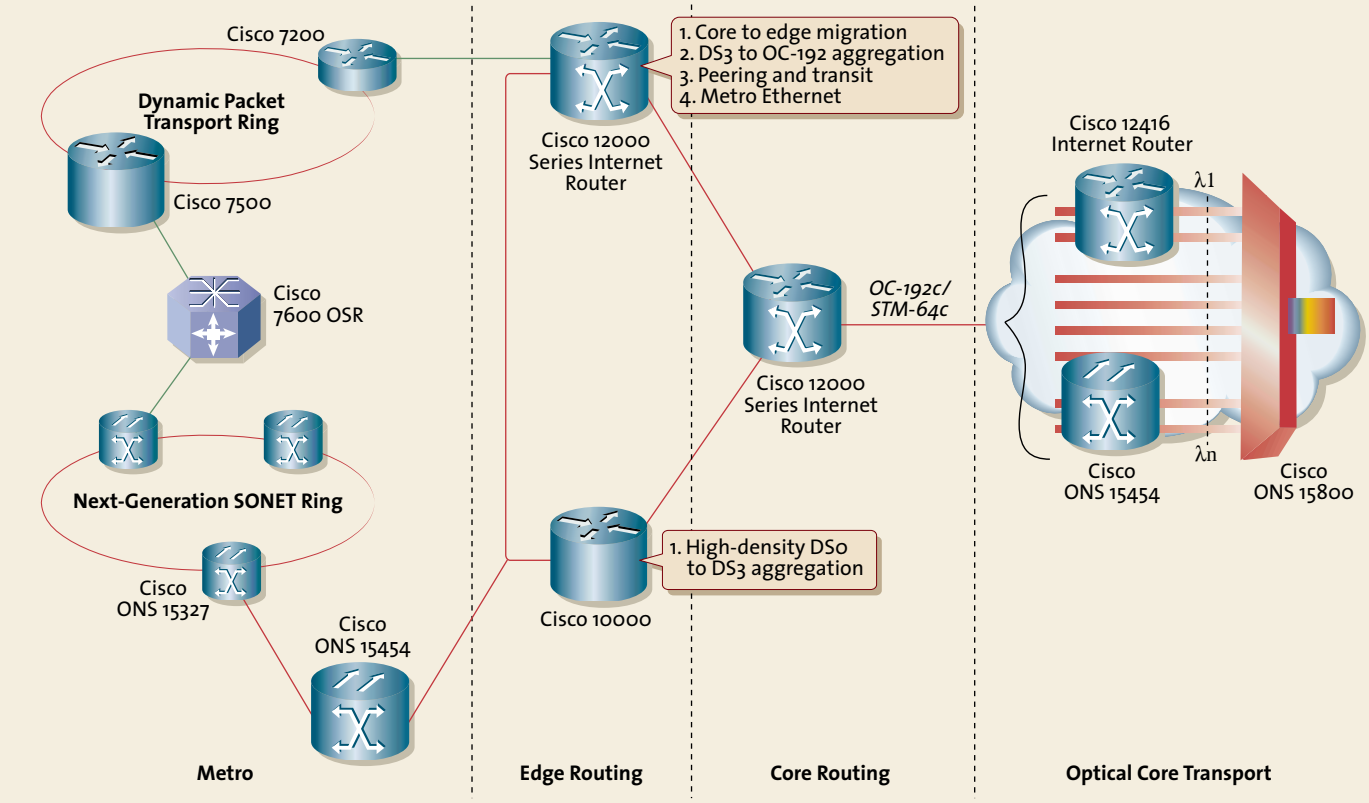
Cisco's IP+Optical solutions expand capacity and provide a foundation for profitable service delivery.

If you want to build a very high-capacity network, go optical. But if you want to build a very high-capacity, intelligent network at the most economical cost per bandwidth unit, you need two technologies: optical networking and IP. The latest generation of optical network solutions has dramatically lowered the cost of deployment, provisioning, and operations over traditional architectures, while IP shines as the de facto standard for business and consumer applications.

The sheer variety and sophistication of today's IP applications require intelligent networks that can support the unique characteristics of data, voice, and video traffic—at blazing speeds. "IP is absolutely critical to any application's success in the future; almost without exception, today's applications take advantage of IP features to deliver such things as quality of service and data recovery," says Roger Farnsworth, director of marketing for Cisco's Optical Networking Group. The connectionless aspect of IP is extremely attractive—just connect to a network anywhere in the world, get an IP address, and you're on line. As the Internet grows, that will only increase in importance. "Some people contend that IP will soon be replaced with pure-wavelength delivery. That's patently ridiculous. When you look at things like multicast, service delivery, and broadband aggregation, it's intelligent network services that are the differentiator and—for the forseeable future—that intelligence can only be provided by electrical, IP-based services."

The proper blend of IP and optical technologies yields a quantum leap forward in capacity, capability, and flexibility. "If

CISCO IP+OPTICAL ARCHITECTURE



LIGHTING THE NEW WORLD: Combining the capacity of optical networking with the intelligence of IP, Cisco IP+Optical solutions give service providers a robust foundation for delivering profitable, value-added services to business and consumer subscribers. The end-to-end architecture has three components: the metropolitan-area network, the service point of presence (edge routing), and the long-haul optical core.

you can incorporate network intelligence into a high-capacity transport network, you can more quickly and easily support new types of IP applications as they become available," says Farnsworth. Cisco offers an end-to-end, IP+Optical networking strategy that gives service providers and enterprises intelligent optical infrastructures that meet these flexible, high-speed application requirements.

The Light of the New World

The Cisco IP+Optical network solution provides the foundation for enabling four major trends in networking today: the explosive growth of broadband and mobile access, voice and circuit integration into packet networks, Internet-scale deployment, and content and services delivery.

- Broadband and mobile access—The exponential growth in aggregate bandwidth of access networks is driving a need for more bandwidth in the metropolitan-area network (MAN). Service providers must accommodate this growth with greater capacity—and fast. Next-generation SONET/SDH solutions are far easier and faster to provision than traditional SONET/SDH, while new dense wavelength-division multiplexing (DWDM) solutions are now optimized for MAN deployments at a reasonable cost.
- Voice and circuit integration—The integration of voice and other circuit-based services into packet networks is inevitable. Yet they are also the primary source of service provider revenues today. Therefore, service providers need networks that continue to enable traditional voice and leased-line services while laying the foundation for advanced new IP services.
- Internet-scale deployment—Service providers desperately need new tools to dramatically lower the cost and time it currently takes to provision new services. By automating labor-intensive, manual functions and eliminating truck rolls, such tools drastically reduce costs and make it possible to rapidly deploy new services in an Internet-scale, mass market.
- Content and services delivery—The heart of the Internet beats with information. New content and service delivery solutions make it possible to support new applications that take advantage of broadband access services and enable profitable new services such as application hosting, multicast, and video on demand.

IP+Optical Architecture

A Cisco IP+Optical network has three primary components: the MAN or metro, the service point of presence (POP), and the long-haul optical core (see figure).

The metro network connects users to

Written by Gail Meredith (gmeredit@sonic.net), a contributing editor for Packet *magazine.*

services. Business and residential subscribers connect to the metro network using a variety of technologies, including dial, ISDN, cable modem, Digital Subscriber Line (DSL), wireless, leased-line services, Frame Relay, ATM, or most recently, 100-Mbps and Gigabit Ethernet. The metro network aggregates customer traffic from multiple access points and connects customers to services in the POP. The metro network must be able to carry packets, cells, wavelengths, or any combination thereof.

The service POP is where most of the IP and application intelligence resides. It is the hub for high-value, packet-based Internet services such as Web-based content, virtual private network (VPN) services, application hosting, cached content, video, and of course, Internet service provider (ISP) services. It is also the transit and peering point into the long-haul core. The service POP is also where most high-performance routing and grooming takes place.

The long-haul optical core is an intercity network designed for efficient, very high-speed transport. The traditional SONET/SDH ring architecture that dominates the core today was originally designed for predictable voice traffic and is proving expensive for data transport. DWDM has altered the core landscape by exponentially increasing fiber capacity to meet the ever-increasing need for bandwidth. Cisco continues to develop technologies that can further optimize the capabilities of the core network.

The Cisco IP+Optical network solution changes the rules, solving several problems associated with legacy optical infrastructures. Unlike traditional SONET/SDH, most Cisco IP+Optical platforms can support a variety of interface types—such as Ethernet, ATM, and DWDM—at speeds ranging from DS0 to OC-192/STM-64. This versatility reduces the number of boxes required compared to a traditional SONET/SDH infrastructure. "Traditional SONET networks present significant challenges because they are complex, slow to build, and expensive," says Farnsworth.

Next, technologies such as Dynamic Packet Transport (DPT) reduce the number of functional "layers" required to operate a fiber network, thus lowering operations costs. Automated provisioning features reduce the number of steps required to provision a service, further lowering costs while significantly accelerating service velocity. "Some IP+Optical platforms take all of 20 minutes to provision from the carton to service activation," states Farnsworth. "In a world where provisioning used to take weeks, these factors represent a radical shift in the economics of optical networking."

By lowering their operating costs, service providers can offer services to enterprises at a much lower cost than they could with traditional optical networks and still realize a healthy profit.

Putting It Together

Cisco's IP+Optical strategy incorporates four complementary development efforts that combine to deliver a solution portfolio that meets the requirements of forward-thinking service provider and enterprise networks:

- Adding optical technology to IP platforms
- Continuing IP and data integration on optical platforms
- Developing an open, standards-based unified control plane (UCP) to further speed deployment and increase efficiencies of IP+Optical networks
- Consolidating network management tools used for IP and optical elements

IP Platforms

The latest advancements in the IP arena are the Cisco 12410 and Cisco 12416 Internet routers with 10-gigabit optical interfaces and the 7600 Optical Services Router (OSR). The Cisco 12410 and 12416 are the newest members of the Cisco 12000 series, the world's most popular family of Internet data center (IDC) and high-speed IP backbone routers. Their distributed processing architecture is highly scalable, and the addition of 10-gigabit per second (Gbps) OC-192c/STM-64c optical interfaces makes them ideal for transit and peering at the edge of the optical core (see "10G: It's Here," page 42).

The Cisco 7600 OSR, based on the Catalyst® 6500 family, delivers high-value IP network services to the optical edge, including a complete lineup of quality-of-service mechanisms in hardware for ultra high performance. Its highly flexible architecture makes it suitable for consolidated POPs, WAN connections from the customer premises, aggregation in the MAN, and service delivery in the IDC (see "Service at the Speed of Light," page 39).

Optical Platforms

Cisco offers several optical transport technologies, including supercharged SONET/SDH solutions, DPT, and DWDM platforms. The staple component of the Cisco SONET/SDH metro network is the Cisco ONS 15454 Optical Transport Platform and its related products (see "SONET Supercharged," page 35). The newest addition to the Cisco optical transport portfolio is the Cisco ONS 15327 Metro Edge Optical Platform, which delivers the same functionality and multiple interface options of the Cisco ONS 15454 in a smaller size for the metro network edge or customer premises.

DPT is available on several platforms, including the Cisco 12000, 7200, and ONS 15190. DPT is suitable for both large service POPs and data-optimized metro rings, while supercharged SONET/SDH adapts existing metro SONET/SDH infrastructures for data, voice, and video transport. Both technologies offer significant technical and economic advantages over traditional SONET/SDH solutions.

DWDM was invented to ease fiber exhaust in the long-haul core; now the technology has been adapted and priced for the metro with the introduction of the Cisco ONS 15200 series. Because DWDM is a Layer 1 technology, providers can build either a DPT or next-generation SONET network atop a DWDM framework to curb fiber exhaust in the MAN.

The traditional long-haul optical core architecture is a ring-based, four-layer "club sandwich" of components: DWDM, then

Continued on page 65

Intelligent Light, *Continued from page 63*

ATM, then SONET, then IP. The long-haul optical core has been enhanced with the Cisco ONS 15800 DWDM Platform, which brings substantially greater capacity to each individual fiber by simultaneously sending data via different wavelengths. Cisco is investigating technologies that will eliminate the "club sandwich" in favor of a more efficient mesh-based architecture.

IP+Optical Unified Control Plane

Despite using the most advanced laser photonics technology available, today's optical networks suffer from old-world provisioning and management methods. In optical transport networks, devices make forwarding decisions based on time slots, wavelengths, or physical ports, and are therefore unable to forward data based on information carried within packet or cell headers. Real-time provisioning does not exist. Optical pathways are nailed up by hand, segment by segment—a time-consuming proposition. There is no traffic engineering at the optical layer. Restoration among multiple layers is uncoordinated.

Fortunately, IP networks hold the key to solving these challenges. IP routing protocols automatically provision and restore pathways. Multiprotocol Label Switching (MPLS) has emerged as the most scalable Layer 3 mechanism for separating traffic into VPNs and for traffic engineering. Its label-based paradigm has the unique advantage of separating the control and forwarding planes in both routed IP and IP+ATM networks. This creates a network provisioning and engineering framework that is independent of the transport layer and network elements. MPLS simplifies network design and operation, dramatically increases service velocity, and significantly reduces provisioning costs.

Cisco is driving the development of a new control plane standard, Multiprotocol Lambda Switching (MPλS), which is based on IP and MPLS. The MPλS-based Unified Control Plane (UCP) makes IP the unifying force in the next generation of high-bandwidth, optical networks. With a single control plane provisioning optical network elements, service providers and enterprises alike can enjoy a faster, simplified service provisioning process with fewer mistakes.

The UCP makes the IP and optical layers of the network aware of and able to talk with one another. It brings the connectionless characteristics and automated provisioning features of IP down to the optical transport layer. It streamlines the number of functional layers required, allowing removal of many areas of functional overlap—a key issue with traditional SONET/SDH networks. The UCP also enables a shift toward mesh-based optical networks (especially in the long-haul core) that support rapid, end-to-end provisioning, fast path restoration, and the bandwidth efficiencies of meshed architectures (see "Taking Control," page 93).

> "I like having one network management system that's talking to all the boxes so I can get circuits turned up in short order."
>
> —BRUCE KOSTRESKI, CTO AND SENIOR VP OF ENGINEERING CAMBRIAN COMMUNICATIONS

Aside from providing IP-like visibility into the optical layers of the network, the UCP substantially reduces the number of protocols. Today, engineers have to be experts in at least three protocol suites—Private Network-Network Interface (PNNI) for ATM, centralized mainframe software for digital cross connects, and Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP) for IP. And that's the short list. Because operations typically represent 60 to 70 percent of the overall cost of running a network, reducing the number of protocols that engineers must touch has a direct impact on operating costs.

Network Management

Cisco IP and IP+ATM service provider networks are managed via components of the Cisco Service Management (CSM) suite. It is no different for Cisco IP+Optical networks. Continuing its strategy of providing modular management applications that integrate with existing, standards-based OSS systems, Cisco offers tools developed in-house, as well as in conjunction with ecosystem partners, to enable a rich, customizable management infrastructure. Cisco Transport Manager (CTM) is an element management system (EMS) for Cisco ONS 15000 series products. The Cisco Element Management Framework provides a common interface to EMS applications such as the GSR Manager for the Cisco 12000 series. Key higher-layer applications that interface with these EMS applications are Cisco VPN Solution Center, which enables rapid provisioning of VPN services based on MPLS, and Cisco Provisioning Center, which supports end-to-end provisioning across multiple Cisco technologies.

Cambrian Communications, a wholesale service provider based in Fairfax, Virginia, plans to use Cisco Transport Manager as part of its Internet operations support system (OSS) when it turns up wavelength services later this year.

"Provisioning is point and click, A to Z. CTM transparently lays the pathway where a signal might pass through several DWDM boxes getting from one end to the other," says Bruce Kostreski, chief technology officer and senior vice president of engineering at Cambrian. "If I wanted to provision an OC-3 circuit between any two points or take an OC-48 circuit, break it up and send it to four cities, CTM makes that very easy and straightforward. I like having one network management system that's talking to all the boxes so I can get circuits turned up in short order."

Lighting the Way

When service providers adopt an IP+Optical networking strategy, both they and their enterprise customers will reap substantial benefits from a radical shift in the economics of optical networking.

"Service providers can enter new markets more quickly with an infrastructure that is

Continued on page 103

Intelligent Light, *Continued from page 65*

intelligent and responsive to change," says Farnsworth. "They will find it less expensive to provision and maintain their infrastructures, and their higher capacity and intelligence will provide unique foundations for profitable services."

With its IP+Optical strategy and solutions, Cisco combines its IP expertise with optical technology to light the networks of the New World.

Service providers that provision services through Cisco IP+Optical networks and enterprise customers that buy those services can meet the demands of 21st century global networking, while enjoying the benefits of much higher service velocities, mission-critical IP network services such as VPN and content delivery networking, and far lower provisioning and operations costs than traditional optical networks. ▲▲

FURTHER READING

For more information on Cisco's IP+Optical strategy and solutions, visit the URL cisco.com/go/optical.

PACKET ADVERTISER INDEX