A Roadmap for Transport Network Modernization

E-Book

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A Roadmap for Transport Network Modernization

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About This E-Book

This E-Book Compares and Contrasts the Transport Networks of Yesterday, Today, and Tomorrow

From the advent of voice and leased line services to supporting the spiraling traffic volumes generated by data, video, and mobile apps, the transport network is suffering somewhat of an identity crisis. It is being called upon to do things it wasn't originally designed to do. In this e-book we look at the background and current state of metro transport networks and the challenges you're facing today and tomorrow as providers.

What are the business and technology requirements of transport networks today and into the next decade? Are there better options for supporting legacy time-division multiplexing (TDM) voice and other services together with IP services in a packetized infrastructure from access to backhaul? There are. We'll show you a next-generation approach using Cisco's high-density circuit-emulation (CEM) technology. As a cost-effective network modernization path for service providers and network operators with ongoing TDM services requirements, the Cisco® solution enables you to dramatically cut OpEx, reduce the cost to deliver a packet, and scale your network for future growth. And you can continue using much of your legacy gear until you're ready to retire it. No radical rip-and-replace is required.

Comparing Our Highway and SONET/SDH Network Infrastructures

Our American road and highway infrastructure was not designed to handle the sheer volume of traffic it sees today. Urban highways have been grossly neglected. Rural roads are patched and repatched to make them passable. Nearly 70,000 bridges in America—one out of every nine—are now considered to be structurally deficient.[1] And then there's the sheer amount of time we lose sitting in traffic: waiting, waiting, waiting.

Our SONET/SDH transport networks are not so different from our aging road and highway infrastructure. Since the birth of SONET/SDH in the 1980s, network traffic has grown dramatically. For a while it worked fine as successive solutions—including add-drop multiplexers (ADMs) and dense wavelength-division multiplexing (DWDM)—were added to better handle legacy and next-generation services and scale. They're comparable to the highway bypasses and overpasses that were added to our road infrastructure. But growing volumes of data, video, mobile, and over-the-top (OTT) traffic are pushing SONET/SDH transport networks to the breaking point. Some legacy infrastructure components, such as the digital cross-connect systems (DCSs), are experiencing high failure rates. Spares to fix them are hard to obtain. High costs for operations and energy eat away at provider revenues. SONET/SDH networks have become just like our crumbling road and highway infrastructure.

It is time for a better transport solution.

[1] "Falling Apart" episode of CBS *60 Minutes*, November 2014.

"There is a surge in demand in the telecom sector for high bandwidth from enterprises as well as individual customers which is shaping the future of the OTN [optical transport network] market. Increased use of Internet for gaming, video calls, online shopping and social media has significantly increased the requirement for high bandwidth, especially in metropolitan cities across the globe. Enterprises are also demanding higher bandwidth from service providers, with the largest requirement coming from financial and government organizations."

– Technavio Market Research Report, *Businesswire*, February 2016

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The Business and Technical Challenges of Legacy Transport Networks

In this E-Book, We're Bridging two Worlds

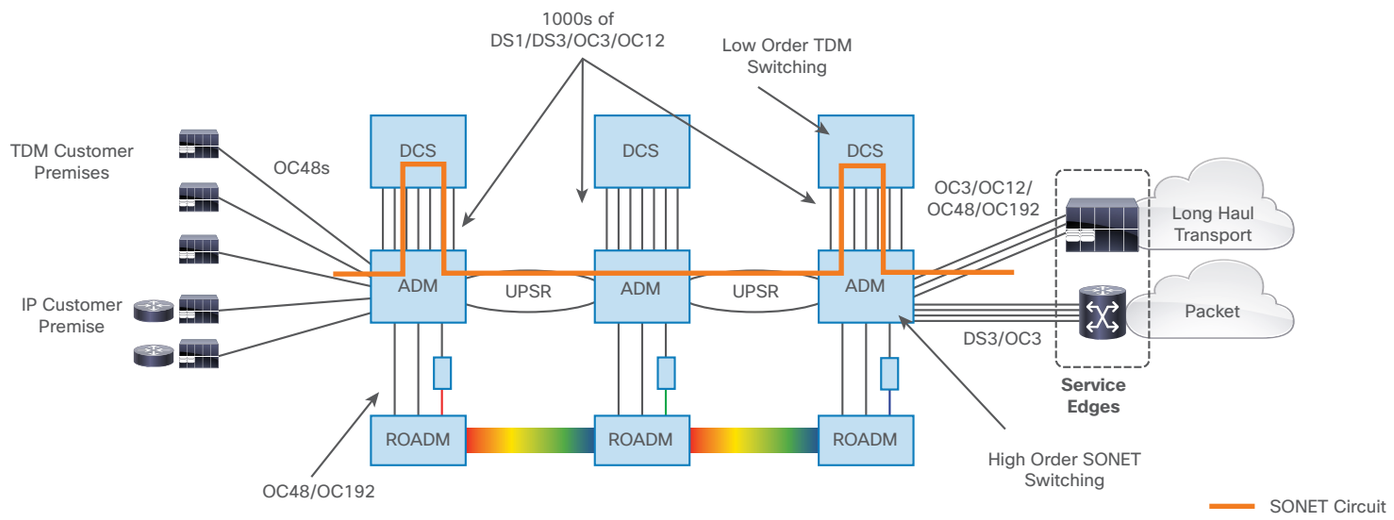
For those with years of optical network experience, you're no doubt familiar with the evolution of SONET/SDH gear and architecture. For those of you who have worked primarily with packet networks, here's a very brief overview.

A Legacy of Innovation

The modern era of optical transport networks dates back to the emergence of fiber optic cable in the early 1980s. It lowered the costs while expanding the capacity and quality of network transport. Early asynchronous networks featured separate clocks timing the transmitted signal for each element. Variation in these clocks led to bit errors. The lack of standards for optical fiber made interconnecting different equipment brands problematic. SONET/SDH provided the needed standards to transfer multiple digital bit streams synchronously over optical fiber using lasers or light-emitting diodes.

Many other improvements followed. Bidirectional line-switched ring (BLSR) and unidirectional path-switched ring (UPSR) to protect high-capacity systems in rings. Digital cross-connect systems (DCSs) to groom traffic at DSO, DS1, and DS3 levels. Wave-division multiplexing (WDM) to allow two systems to share a fiber and then dense wave-division multiplexing (DWDM) to enable 80 times that number. Add-drop multiplexers (ADMs) and reconfigurable optical add-drop multiplexers (ROADMs) to combine lower-bandwidth data streams into a single beam of light and to add or drop data channels from a transport fiber without needing to convert the signals on all WDM channels to electronic signals and back to optical signals.

Figure 1. A Legacy Optical Transport Network with TDM and IP Services



Exponential Growth

Tremendous growth of IP traffic, connected devices, transport speeds, and electrical consumption will only increase in coming years:

- Global IP traffic will grow at a compound annual growth rate (CAGR) of 22 percent from 2015 to 2020, when it will reach 2.3 zettabytes annually.
- The number of devices connected to IP networks will be more than three times the global population by 2020: 26.3 billion devices, up from 16.3 billion in 2015.
- Broadband speeds will nearly double between 2015 and 2020, going from 24.7 Mbps to 47.7 Mbps.
- Data center electricity consumption in the United States is projected to increase from 91 billion kilowatt hours annually in 2015 to 140 billion by 2020, the equivalent output of 50 power plants, costing American businesses $13 billion and emitting nearly 100 million metric tons of carbon pollution per year.
- Digital content, big data, e-commerce, and other Internet traffic are turning data centers into one of the fastest-growing users of electricity in developed countries.

Sources: Cisco Visual Networking Index: Forecast and Methodology, 2015–2020; National Resources Defense Council research.

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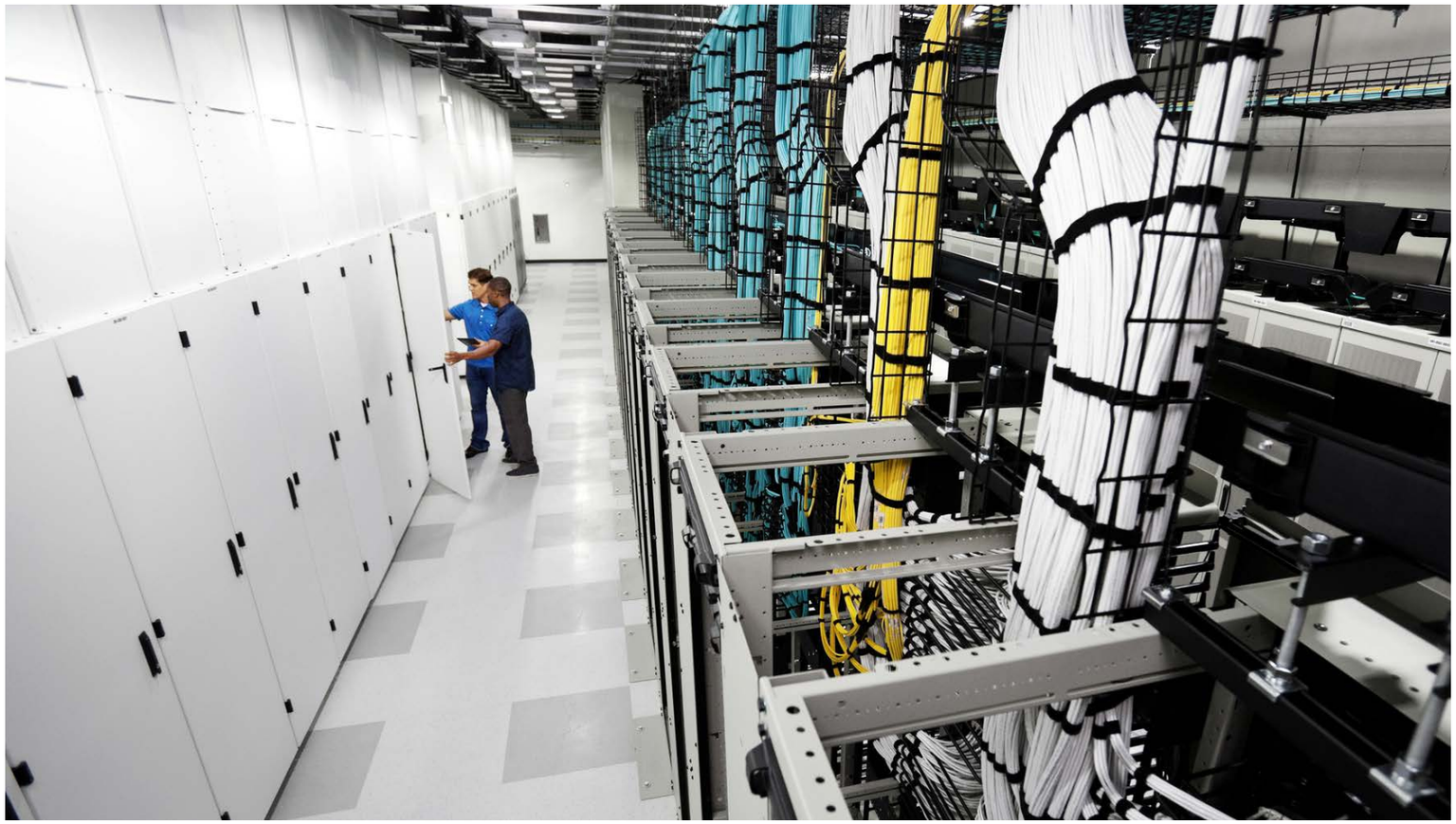
The Good, the Bad, and the Ugly

Along the way, Ethernet and IP multimedia traffic was added to the circuit-switched TDM traffic. Video services have been an area of particular growth and massive resource consumption. Cisco helped our customers handle the load with the addition of a packet network. Aggregation of the traffic from cable modem termination systems (CMTSs), digital subscriber line access multiplexers (DSLAMs), or optical line termination (OLT) was handled over an aggregation router, which then brought the traffic back to the central office.

However, as this approach proliferated, the limitations of legacy optical transport networks became clear. With rings, an any-to-any topology is not possible. To provision the network, the command line interface (CLI) was used: Transaction Language 1 (TL1) for the operational support system (OSS). This manual approach proved to be cumbersome, requiring circuits to be set up one at a time. This is why it can take months to turn up a circuit. As a result, time to market and time to revenue are very slow. These transport networks are a generation old, and fundamental network elements such as DCSs are reaching end of life.

Figure 2. A typical large service provider's central office has 100 racks of gear drawing 200,000 kilowatts of power. The total cost of space and power for the environment is $975,000 a year, according to Cisco estimates.



What's Wrong with Legacy Transport Networks? Count the Ways

Much of the infrastructure in optical transport networks is working, and innovations continue, but major problems within the legacy SONET/SDH architecture are now becoming clear. Today legacy transport networks:

- Are operating at near maximum capacity, while the parallel or overlay packet infrastructure has a high percentage of excess unused capacity
- Include equipment experiencing high failure rates such as the aging DCS, which is also approaching its end of life
- Are unable to scale to meet the demands of today's growing volumes of Ethernet and IP multimedia traffic as well as bandwidth-intensive apps and services
- Require high CapEx and OpEx to maintain and grow the network to accommodate demand
- Incur high costs for infrastructure footprint, power, and cooling
- Include multiple, complex management systems that often require cumbersome manual processes and result in delays and inefficiencies
- Must adapt to effectively compete against OTT players

Additionally, service revenues are not growing in proportion to demand for multiservice transport, so the business equation isn't working anymore. A transport network modernization strategy that is easy to use; lowers TCO; and meets next-generation requirements for efficiency, speed, scalability, and performance is vital.

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Defining Requirements for the Next-Generation Transport Network and Evaluating Modernization Solutions

First, on What Is Your Transition Plan Based?

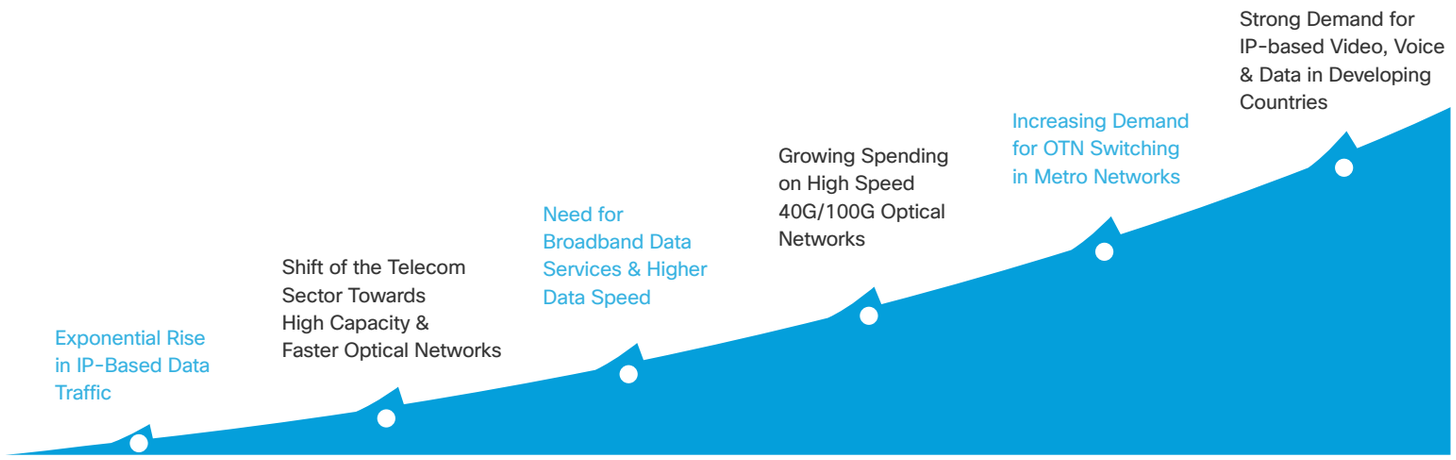
For many of you, a significant percentage of your customer traffic flows through TDM interfaces. At the same time, multimedia IP traffic is dramatically increasing. Your ultimate goal is to transition to an all-packet network before your legacy infrastructure becomes obsolete. But that won't happen overnight. In the meantime, a prudent approach is to transition to a hybrid network supporting TDM, Ethernet, and IP. You need a solution with a long lifespan, one that will lay the foundation for your next-generation transport network. To begin the search, here are some of the important requirements you should be considering.

Next Generation, Carrier Class

Your business has unique requirements and challenges. But there is a core set of requirements for a modernized carrier-class network that you share with all service providers businesses. Assessing different transport modernization solutions based on these requirements is a helpful exercise.

You can do this in conjunction with other factors. These include assessing the current state of your legacy technology infrastructure, the size of your business, your geographic location, customer demographics, and the competition in your market.

Figure 3. Global Market Drivers for Optical Transport Networks



Source: Global Industry Analysts, Inc., February 2015.

Requirements Checklist for the Next Generation Transport Network

- **Minimize effects on legacy infrastructure services,** including maintaining existing service SLAs and using existing customer premises equipment (CPE) to decrease customer churn rates.
- **Launch new service offerings,** including new IP and Carrier Ethernet services.
- **Reduce OpEx requirements,** including costs for space, power, and maintenance as well as the cost per bit to deliver traffic through the integration of next-generation technology.
- **Support SLAs,** including the industry standard 99.998 percent SLAs for uptime, and 50ms timing for voice, and the use of scalable technology such as DWDM to support an anticipated 50 percent annual bandwidth growth rate.
- **Reduce CapEx while maintaining support for critical network management,** including business-critical operational features (for example, bit error rate testing (BERT) and loopback testing) whose local and remote controlled test equipment can be eliminated; integration with existing OSS/BSS systems; and comprehensive TDM and IP service lifecycle management.
- **Support a simple, robust implementation** through the automation of the solution deployment, thereby minimizing effects on end customers, existing services, and maintenance windows.

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Solution Options for the Next-Generation Transport Network

Native TDM Switching over OTN

Overlay with Routers and DWDM

Packet Optical with Circuit Emulation

Do Nothing

There are a number of options for modernizing your transport network, including native TDM switching over the optical transport network (OTN), a complete overlay network with routers and DWDM, migrating to packet optical using circuit emulation (CEM), and of course remaining with the status quo and doing nothing. Each option has value, but the value depends on your ultimate end goal.

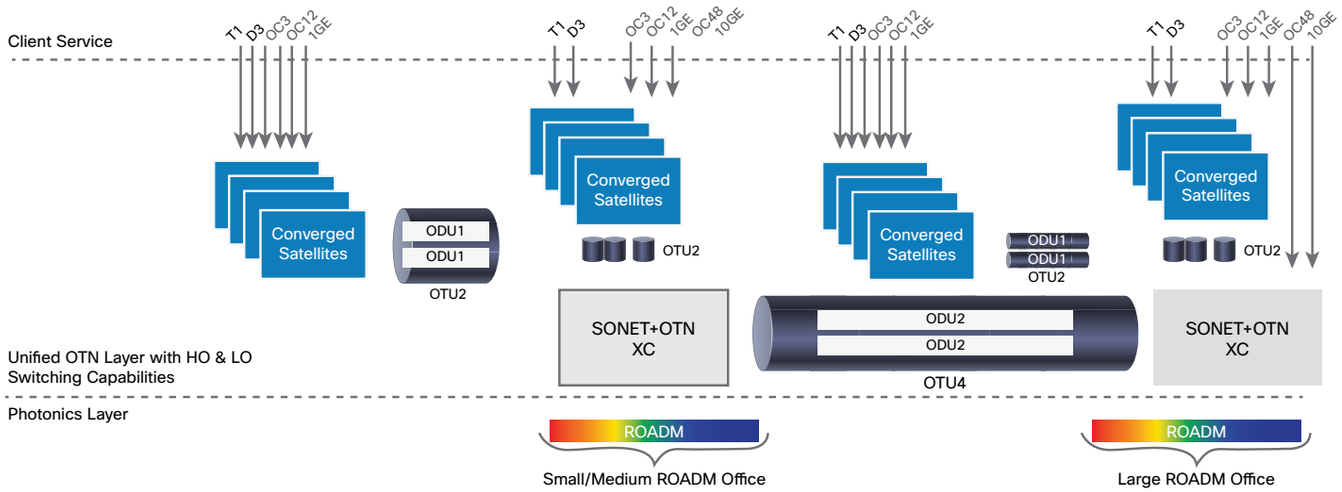
If you don't have a lot of TDM connections and related infrastructure in your network and central office, retooling to provide a next-generation transport network is simpler and more cost-effective. For those with extensive TDM services to support, a more gradual migration to a transport network that supports TDM, Ethernet, and IP/packet services is the prudent way to move forward.

Native TDM Switching over OTN

Go Native

With a modernization project featuring native TDM switching over the OTN, the OTN switch becomes a way to backhaul TDM traffic. T1, DS3, OC3, OC12, 1 Gigabit, and 10 Gigabit connections are multiplexed for transport over an optical data unit (ODU) connection. Native TDM Switching over OTN lets you retain TDM interfaces while using OTN and low-speed interfaces for transport. When Ethernet is added, however, the solution begins to become much less efficient. The low-density ASICs in a SONET platform only allow for 40 to 60 gigabytes of low-order/high-order (LO/HO) switching. Capacity utilization on each system is limited to a maximum of approximately 40 percent. This solution is not viable for packet traffic, which requires a more expansive environment for traffic diversity and overall traffic and bandwidth growth. The SONET cross-connect can only be connected to a maximum of 16 destinations, limiting scale. And OpEx is high given the complexity of the SONET/SDH over OTN grooming solution. OTN is not optimized for LO/HO grooming of containers within the SONET payload because of hardware capacity limitations.

Figure 4. Native TDM Switching over OTN



Bottom Line: This solution is very inefficient because it does not utilize the available capacity in your network and limits scale. It allows you to maintain the TDM infrastructure at the expense of efficiently adding Ethernet traffic and is not expandable to include next-generation IP traffic.

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Solution Options for the Next-Generation Transport Network

Native TDM Switching over OTN

Overlay with Routers and DWDM

Packet Optical with Circuit Emulation

Do Nothing

Overlay with Routers and DWDM

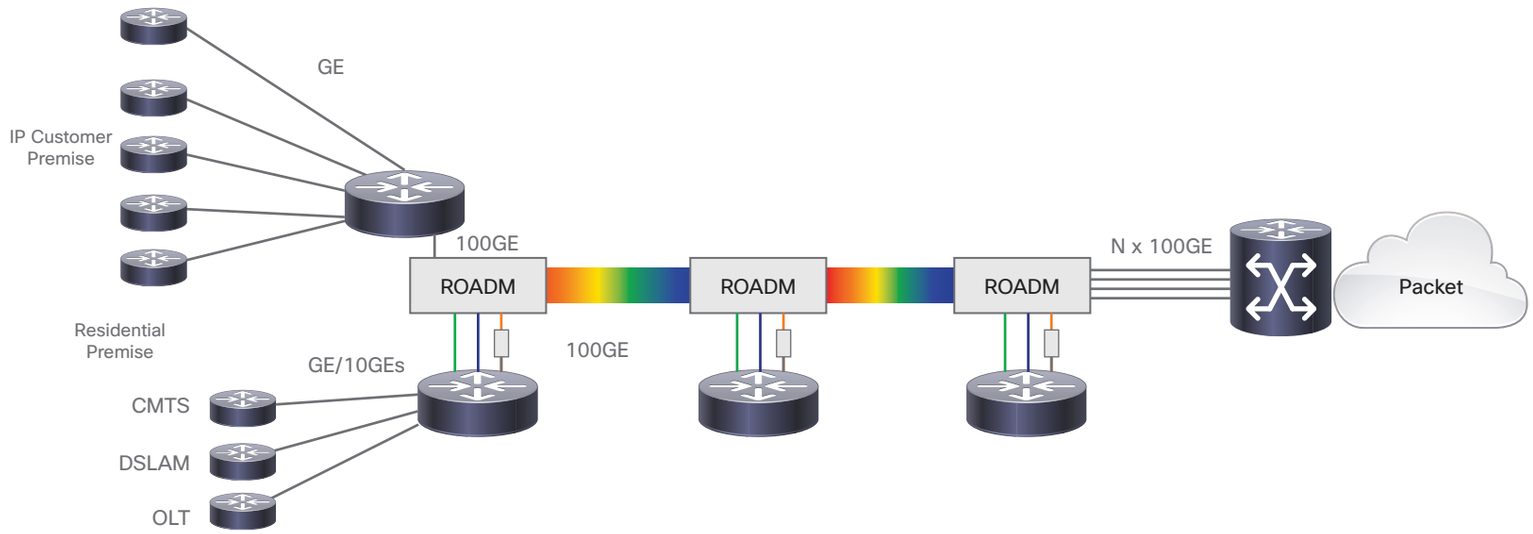
Eliminate all of your TDM Interfaces

It's going to be disruptive and expensive for your customers. An Ethernet-only network requires that you change your optical carrier technology (for example, OC3 or OC12) to Ethernet to support packet. This will, in turn, force your customers to buy new CPE devices. Will they agree to incur that expense? Will they also adjust their operations environments to support the new interface? Or will they find another provider? Again, instead of a gradual migration to a hybrid network, this option means getting rid of TDM interfaces and a lot of SONET/SDH gear and replacing them with Ethernet technology. This will incur additional expense for your customers.

In this situation, why wouldn't your customer consult another provider more experienced in Ethernet services? Especially if your customer is a small company, what is its incentive to invest in the changed network?

Other major questions will have to be answered: How will this new network be managed? Will it support a 99.999 percent SLA for uptime and 50ms protection for voice? How? Will voice over IP (VoIP) provide the proper timing for voice?

Figure 5. Overlay Network with Routers and DWDM



Bottom Line: This option does not provide a gradual migration to the next-generation transport network. It does not support TDM, Ethernet, and IP traffic. The solution will require a great deal of expertise both within your organization and among your customers. It will also be expensive and might take a lot of time to implement. It's a very risky strategy that has the strong potential to significantly increase customer churn.

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Solution Options for the Next-Generation Transport Network

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Do Nothing

The Perils of Customer Churn

According to recent research, annual customer churn rates among North American network subscribers were approximately 21 percent for residential customers and 15 percent for businesses. For example, service providers with 2 million subscribers for both categories annually incur 420,000 and 300,000 lost customers, respectively. Add to that the expected additional churn (20 percent? 50 percent? higher?) from a revamp of the transport network based on the requirement that customers purchase new CPE. Then add the cost of new transport infrastructure. The results could have a devastating effect on service provider revenues.

> *Communications Monitoring Report,*
> CRTC, October, 2015;
> *Breaking the Back of Customer Churn,*
> Bain & Company, 2014.

Packet Optical with Circuit Emulation

Highly Cost-Effective, Robust, Next-Generation, and Invisible to your Customers

With circuit emulation, TDM services can be migrated across an asynchronous IP/Multiprotocol Label Switching (MPLS) network with no errors and a constant delay. CEM provides the ability to terminate TDM traffic over SONET/SDH as an interface, continuing fault propagation between SONET/SDH and the IP/MPLS network using pseudowires running over dynamic label-switched paths (LSPs). LSPs are paths through MPLS networks set up by a signaling protocol. The CEM solution is supported by multiple industry standards and deployed through control planes for both SONET/SDH and IP/MPLS.

How Circuit Emulation Works

1. Raw TDM frames are generated by the TDM endpoint and transmitted toward the controller on the CEM router.
2. The CEM router receives the raw TDM frame, adds on SAToP or CEP encapsulation, adds on the MPLS shim header, and then transmits the frame toward the MPLS core.
3. The MPLS core label-switches the frame based on the LSP that was set up when the pseudowire was established between the two CEM endpoints.
4. The receiving CEM endpoint receives the frame and associates it with the appropriate CEM group based on the received label. The frame arrives at the CEM group dejitter buffer and waits to play out to the TDM controller at clock rate.
5. The CEM router serializes the frame from the dejitter buffer toward the TDM endpoint.

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Solution Options for the Next-Generation Transport Network

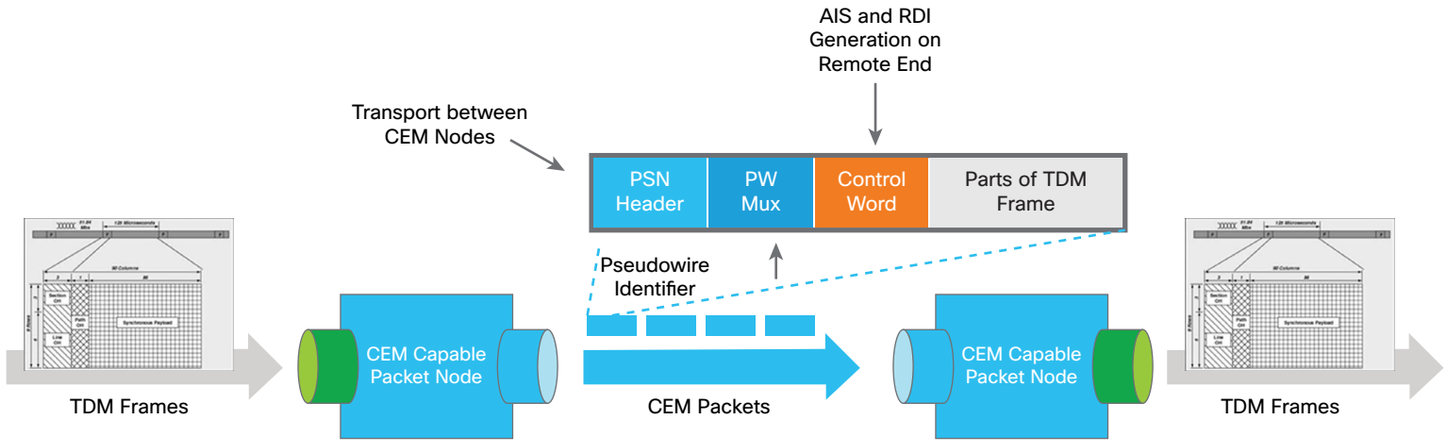
Native TDM Switching over OTN

Overlay with Routers and DWDM

Packet Optical with Circuit Emulation

Do Nothing

Figure 6. A CEM-enabled Device Converts TDM Frames to Packet and Then Back Again to TDM



CEM uses different methods based on TDM service type to transport different types of TDM traffic over the packet network:

- Structured agnostic TDM over packet (SAToP) uses a pseudowire to transport T1, E1, T3, and E3 circuits.
- Circuit-emulation service over packet-switched network (CESoP) uses a pseudowire to transport structured (NxDS0) TDM signals.
- Circuit emulation over packet (CEP) uses a pseudowire to transport SONET/SDH.

SONET/SDH-Like Features

The CEM solution provides protection; operations, administration, and management (OAM); simplicity; and manageability on par with those provided by SONET. It is predictable and deterministic, with sub-50ms resiliency. IP/MPLS packet services run natively over the network.

With the high-density CEM solution, TDM traffic is restricted to the edges, and IP/MPLS is added as the major transport network. The scalable MPLS infrastructure is overlaid on top of the 100GB ROADM and reconfigurable OTN DWDM. infrastructure. With a SONET look and feel, one-to-one path protection, and an A to Z provisioning system, the CEM solution lets you trim down your legacy transport network as part of a next-generation migration. DCSs can be eliminated right away, dramatically reducing costs. SONET ADMs may be eliminated now or later. With Gigabit Ethernet over SONET, Gigabit Ethernet routers may also be taken away or reduced. You'll be able to use 1/10 the space you're using now in your central office and get rid of thick electrical cables running between floors. No need to cannibalize other systems to keep other legacy gear running or buy expensive replacement parts, if they are even available.

Meanwhile, your customers can continue using the same CPE and might not even realize that you're enjoying major new ROI and a host of other benefits after modernizing your transport network.

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Solution Options for the Next-Generation Transport Network

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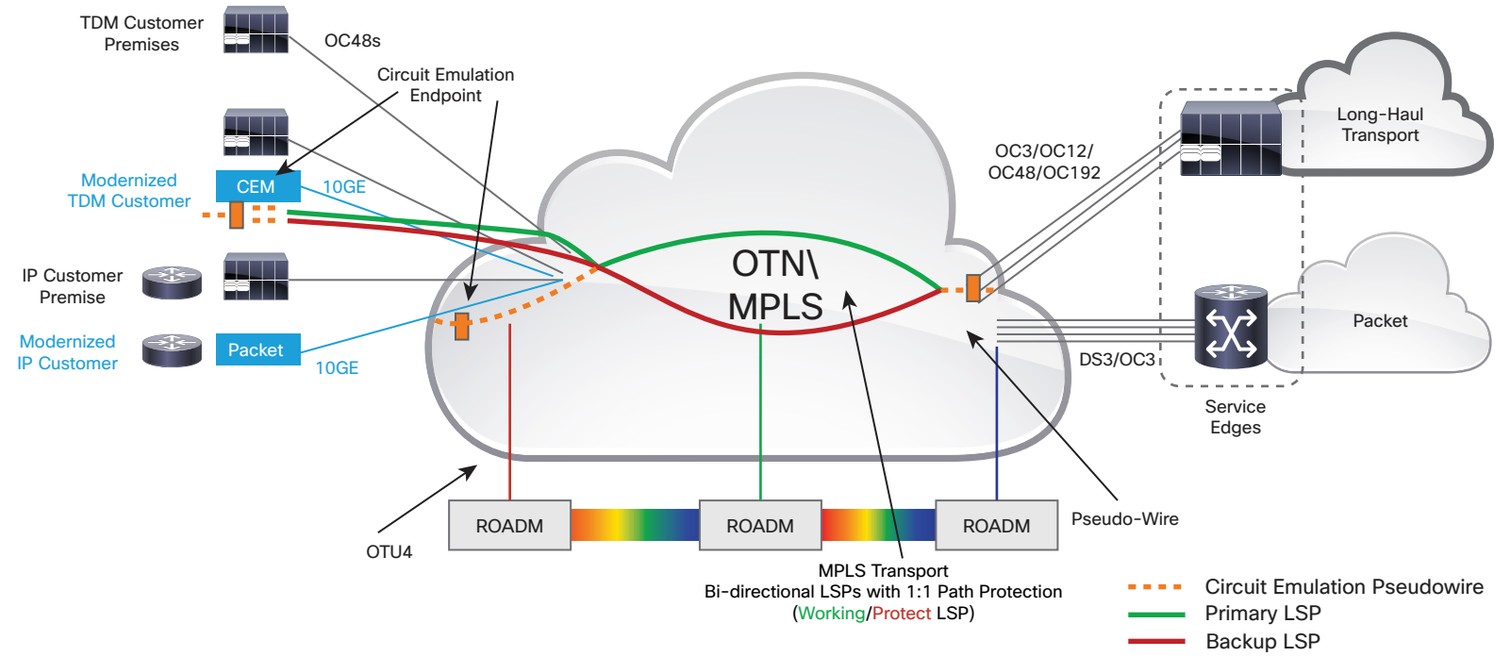
Packet Optical with Circuit Emulation

Do Nothing

Figure 7. TDM and IP Services Moving Through a Modernized Transport Network Using Circuit Emulation



How Is 50ms Resiliency Achieved? Protection Switching

Associated bidirectional LSPs, an adaptation from MPLS-Transport Profile (MPLS-TP) standards, borrows the concept of one-for-one protection switching and an active and standby path with a bidirectional forwarding detection (BFD) session running. This enables hardware acceleration at a 3.3ms frequency, and it provides a bidirectional tunnel into which the pseudowire is mapped. If there is a midpoint link failure between the source and destination of the circuit, the loss of signal (LOS)–triggered LSP feature is activated. The standby LSPs then become active.

CEM Over MPLS Beats CEM Over Ethernet

MPLS provides much greater scale for CEM than any other solution. To connect CEM devices using OTN and a ROADM mesh or a VLAN would require thousands of access nodes for a fully modernized metro transport network. Applying the n^2 rule for 1000 CEM nodes would result in 499,500 logical adjacencies. That would create a huge challenge to management and scalability. By contrast, a distributed MPLS, OTN, and ROADM mesh allows for the efficient aggregation of services. At the IP services edge, routers running MPLS are fully integrated with the next-generation metro network. The CEM devices use MPLS to scale. The ROADM infrastructure can dynamically build 100G channels between sites. Distributed MPLS switching allows for the efficient aggregation of packet services. It's the only way to scale efficiently and economically through a flat, distributed network.

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Solution Options for the Next-Generation Transport Network

Native TDM Switching over OTN

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Do Nothing

Bottom Line: This solution allows TDM services to be integrated along with IP services across SONET/SDH transport networks. IP/MPLS and other technologies help eliminate errors and delay. You get SONET/SDH-like features, such as OAM and manageability. Your next-generation transport network becomes predictable and deterministic, with sub-50ms resiliency. The solution is supported by industry standards. It's invisible to end customers, with no new CPE required. Packet optical with CEM is a great way to modernize, scale, trim OpEx and CapEx, and future-proof your transport network. It lets you evolve towards Metro Ethernet, Layer 3 VPN, and full IP transport whenever you're ready.

Do Nothing

Waiting for Things to Get Worse is Never a Good Strategy

With packet switching accepted as the state of the art and new approaches, applications, and technologies such as programmable networks, the Internet of Things (IoT), and 5G coming, the old ways of doing things are quickly disappearing. Transport networks are straining to handle the onslaught of IP multimedia traffic, and the forecasts show volumes and bandwidth demands climbing higher and higher. Repairing aging equipment in legacy transport networks is extremely expensive and difficult, as platforms such as DCSs are reaching end of life. Manual-intensive operations significantly slow your ability to deploy, modify, and charge for services.

Bottom line: The costs to maintain your transport network as is and the lost opportunity costs from your inability to respond to new customer requirements make doing nothing an option few if any service providers should seriously consider. The transport network is ripe for change, and finally a viable, cost-effective migration path based on industry standard solutions is available to you.

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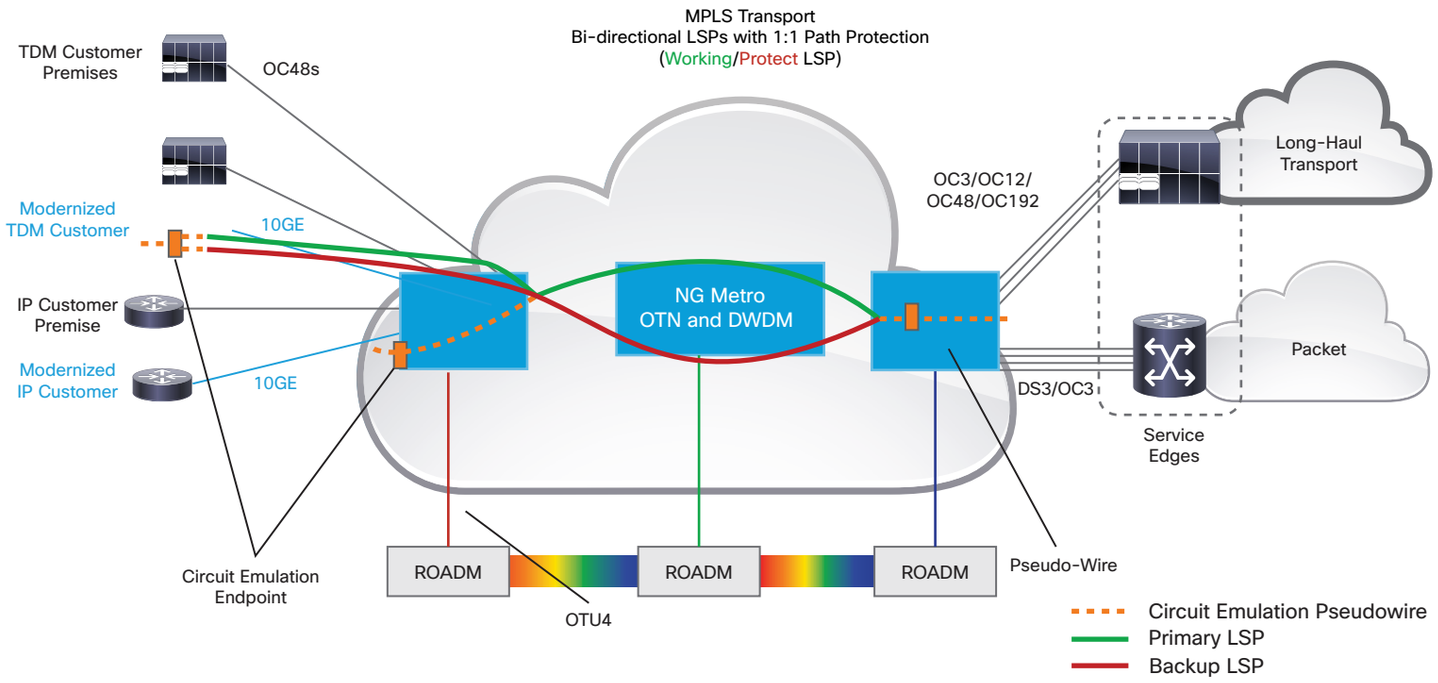
Cisco Transport Network Modernization Solution

Technology, Products, and Architecture for Next-Generation Transport Networks

Our solution is carrier-class. It's designed for a migration at your pace from TDM and SONET/SDH to 100 percent packet services. It's the Cisco Transport Network Modernization solution.

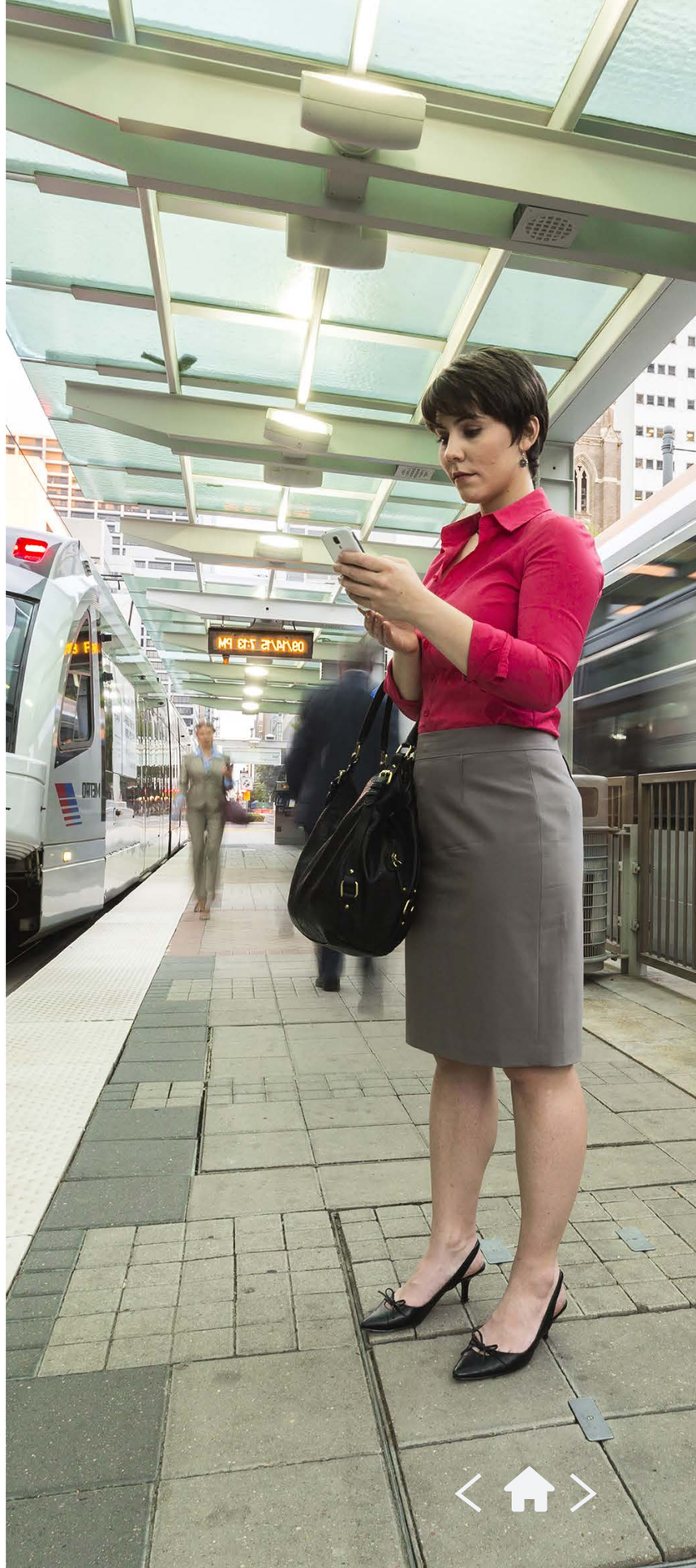
Are you ready to replace aging DCS and ADM hardware while still maintaining your legacy TDM services? We'll show you how with our industry-leading high-density CEM technology. Because the Cisco solution is built on a packet-based architecture, you can maintain your legacy TDM services as long as they are required. When you're ready, transition to a 100 percent packet-based transport network.

Figure 8. Cisco Transport Modernization Solution: Technology View



The Cisco solution includes these technologies:

High-density CEM technology: Cisco's high-density CEM technology provides boundless scale over a protected FlexLSP core. Cisco CEM technology is enabled by the Cisco NCS 4200 series transport hardware. Because the high-density CEM technology traverses the MPLS transport network using pseudowires, we are not bounded by any technology protocol limits, as we would be with either an OTN- or VLAN-based transport network. Instead, the network can scale to support as many pseudowires as are required simply by adding additional Cisco NCS 4200 series hardware.



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Fully distributed MPLS core network: A fully distributed Cisco MPLS core network supports the sub-50msec timing requirements of the CEM technology and provides great scale of services for router backbone connections and business access to IP services. It is also preferable to an OTN/ROADM mesh core because packet layer logical links and adjacencies are minimized. By comparison, an OTN/ROADM mesh core would result in an N^2 problem, where every CEM device needs to have a logical adjacency to every other circuit and box. This is not easily managed or scalable.

OTN: Cisco OTN switching technology includes full optical channel data unit level 0 (ODU-0) switching with ports supporting SONET/SDH, Ethernet, and channelized OTN.

ROADM: Cisco nLightTM ROADM technology supports limitless DWDM flexibility through colorless, omnidirectional, contentionless add/drop capability complemented by flex-spectrum scalability. This lets your network instantly respond to new bandwidth requests, route around network failures, and dynamically adjust topologies to help ensure robust network performance, all without the need for manual intervention.

DWDM: DWDM is a crucial component of optical networks because it maximizes the use of installed fiber cable and allows new services to be quickly and easily provisioned over existing infrastructure. Flexible add/drop modules allow individual channels to be dropped and inserted along a route. An open-architecture system allows a variety of devices to be connected, including SONET terminals and IP routers.

Cisco Transport Modernization Solution: Products

Cisco Network Convergence System (NCS) 4200 Series

Addressing the inefficiencies at the network edge, this transport system utilizes high-density CEM technology to convert TDM services into pseudowires, which then facilitate the transport of TDM services over a scalable MPLS core network. With this technology, service providers can keep their existing operational models and service revenue while running all their services over an IP network.

Cisco NCS 2000 Series

With its flex-spectrum ROADM, the Cisco NCS 2000 sets the industry benchmark for DWDM solutions. It delivers the touchless programmability, massive scale, and flexibility required to optimize both metro and ultralong-haul performance.

Cisco NCS 4000 Series Converged Optical Service Platform

The Cisco NCS 4000 anchors a converged packet optical infrastructure by providing DWDM, OTN, MPLS-TP, Carrier Ethernet, and IP multiservice capabilities.

NCS 4000 Series
Non-blocking agnostic fabric
Multi-chassis capable
Coherent DWDM interfaces
GMPLS/MPLS Control Plane

NCS 2000 Series
Amplified, CDC, ROADM system
Coherent DWDM Interfaces
GMPLS Control Plane

NCS 4200 Series
Ethernet/SONET/OTN/CEM
MPLS Control Plane

The NCS family of products include a consistent feature set, common MPLS framework and proven interoperability with traditional packet platforms

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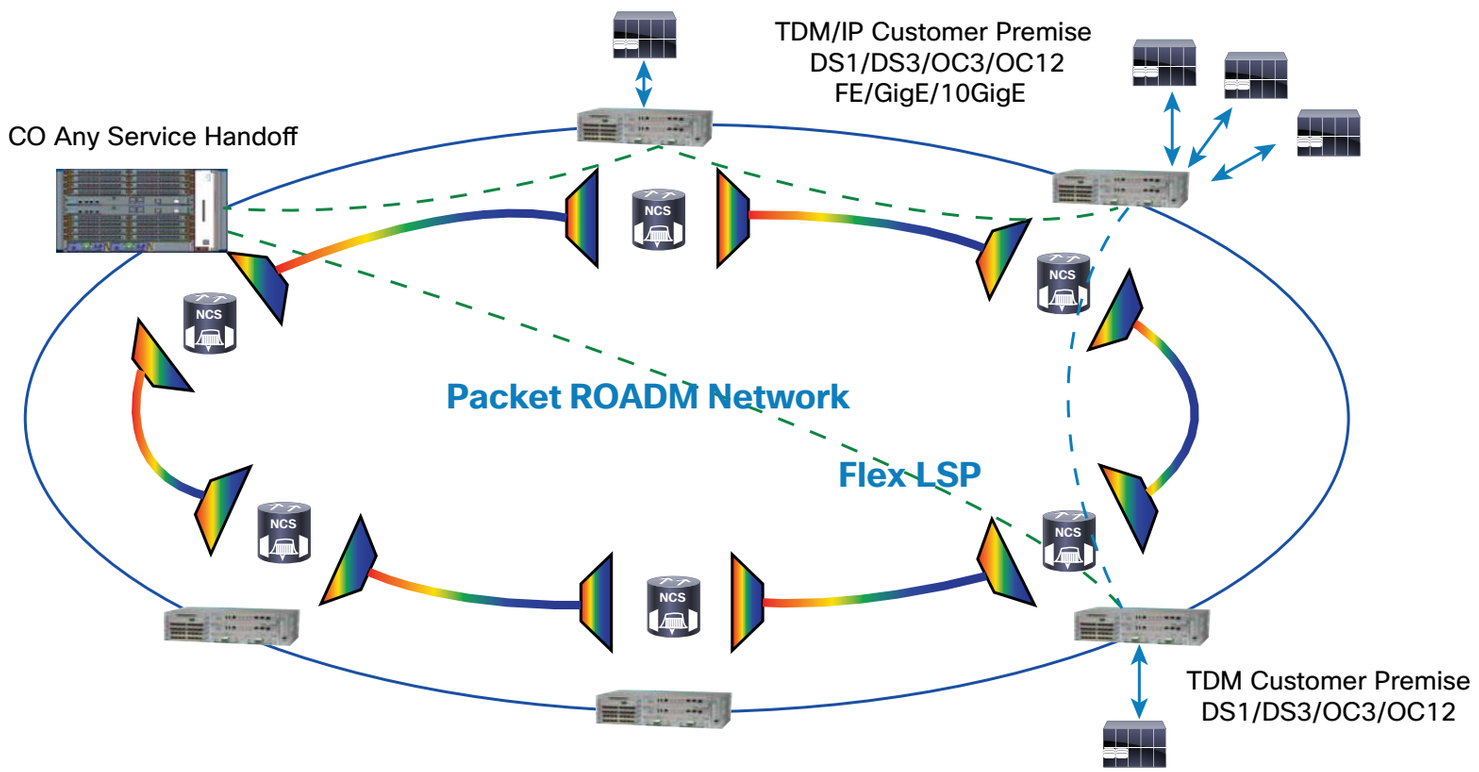
Cisco Evolved Programmable Network Manager (EPN-M)

Cisco EPN Manager helps service providers to modernize circuit transport and private line networks by addressing the combination of CEM over packet, OTN, and DWDM/ROADM networks with comprehensive end-to-end network management support. This all-in-one, next-generation product provides device management, network provisioning, and network assurance across converged packet-optical networks.

The Cisco Solution Can Be Used to Migrate These Architectures

SONET ADM ring overlay/migration: The NCS 4200 and NCS 2000 replace the aging SONET ring as an overlay with a low-cost packet ROADM architecture. With the NCS 2000, DWDM is used to mitigate the need for a second fiber pair. The low cost of DWDM modules combined with state-of-the-art packet switching allows complete flexibility for service delivery. This new architecture provides full any-to-any capability, full hierarchical quality of service (QoS), and throughput control (for example, oversubscription). In addition, there is no time slot bounding through the transport path, and it lets you use an already lit fiber path, if required.

Figure 9. Example of a SONET ADM Ring Overlay Migration



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Legacy DCS and ADM retirement: The NCS 4200 replaces the functionality of DCS and ADM components. You get a nonblocking, protocol-independent fabric architecture and boundless scale through the use of high-density CEM over a protected Flex LSP core. The power and space requirements of the DCS are cut by nearly 90 percent based on the small footprint required for the NCS 4200. You benefit from significant space, power, and cooling savings. This architecture integrates into both TDM and MPLS packet core networks.

CEM + Carrier Ethernet over existing IP core network: NCS 4000 and NCS 4200 transport hardware can be added at the edge to provide CEM services across the MPLS core. This lets you transport any service from one location to another. It is a purpose-built solution that supports high-density TDM and Carrier Ethernet. And it provides any-to-any-connectivity using a packet-switched network not bounded by TDM transport inefficiencies. You utilize existing equipment in the IP/MPLS core to gain unbounded scale with MPLS/Flex LSP versus less efficient packet transport mechanisms.

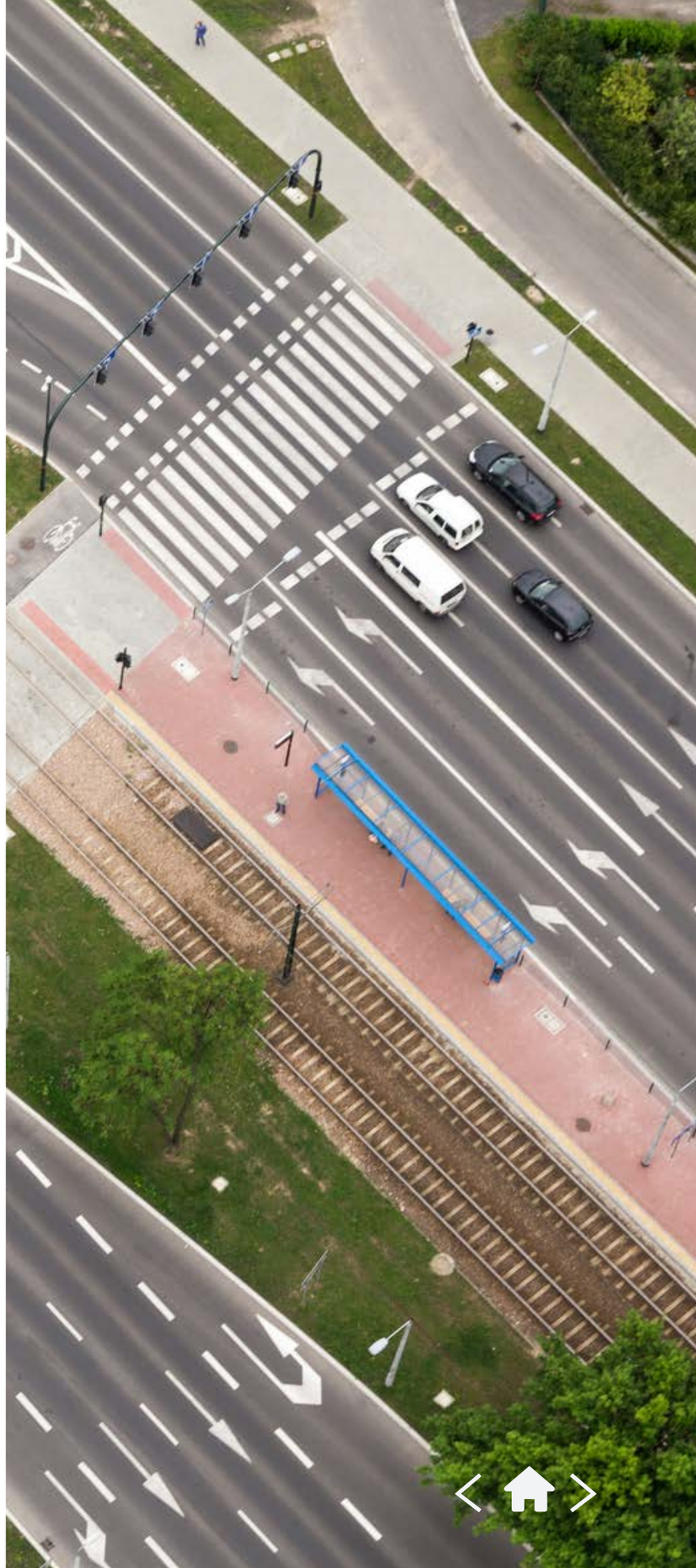
Complete central office modernization A to Z: With a greenfield setup, the NCS 2000 and NCS 4000 are deployed to provide colorless, contentionless, omnidirectional, and Flex Spectrum (CCOFS) ROADM technology, OTN, and MPLS capabilities. After the metro core is established to provide high-capacity OTN and Ethernet switching and a 100G colorless, directionless, and contentionless (CDC) ROADM intelligent photonic layer, the metro access, aggregation, and satellite network segments are added. All links are MPLS enabled, and associated LSPs are used to transport the NCS 4200 pseudowires from A to Z. Cisco EPN Manager provides a multilayer view of the network using a single tool. You can also eliminate the need to adhere to OSMINE (Operations Systems Modifications for the Integration of Network Elements) compliance for alarming and provisioning. OSMINE is unable to recognize or manage advanced hardware functionality. EPN Manager provides all the functionality you need end to end, including managing CDC ROADMs.

Grading the Cisco Transport Network Modernization Solution

Returning to our business and technical requirements checklist, let's take a look at how the Cisco solution would help you to reach your business goals.

As a reminder, the requirements address the effects of a new solution on an organization's business model, future growth opportunities, OpEx and CapEx targets, and integration into existing operational models (including staffing, skillsets, and OSS/BSS in use).

Effects on legacy infrastructure: With the high-density CEM capabilities of the NCS 4200, you can continue to offer the same TDM services to your customers. The combination of MPLS and NCS 4200 supports the sub-50msec timing requirements of voice services and supports a transport network that can maintain existing SLAs. Because this solution is completely transparent to the end user, there are no forced migration of CPE devices and no effect on your customer churn rate.



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Ability to launch new service offerings: The Cisco solution supports the service flexibility and delivery of Carrier Ethernet Layer 2, Layer 3, and IP. In addition, it supports MPLS transport for advanced Layer 2 VPN, Layer 3 VPN, and multicast services. Cisco EPN Manager can be used to provide comprehensive end-to-end management of those services alongside the management of your OTN.

Reduced OpEx requirements: With the high-density CEM capabilities of the NCS 4200, the Cisco solution can replace the aging DCS and ADMs in your network, resulting in a 90 percent reduction in OpEx (space, power, and maintenance) costs. Through the combination of the NCS 2000 providing best-in-class DWDM technology and the NCS 4000 providing the MPLS network foundation, the Cisco solution can scale to deliver a very efficient network, reducing the cost to deliver a bit by up to 50 percent.

Lower CapEx requirements: If needed, you can use Cisco Capital® financing to cost-effectively acquire the technology needed to achieve your objectives and stay competitive. Cisco Capital can help you reduce CapEx, accelerate your growth, and optimize your investment dollars and ROI.

Broad support of service levels and new and old technologies: With the NCS 4200's TDM service capabilities and a robust MPLS network using RSVP-TE with transport enhancement, the Cisco solution meets the industry standard 99.998 percent SLA and 50ms requirement timing for voice services. Through the combination of the NCS 2000 with best-in-class DWDM technology and the NCS 4000 providing an MPLS network foundation, the Cisco solution can efficiently scale to meet a 50 percent annual traffic growth rate. With Cisco EPN Manager's comprehensive end-to-end optical management capabilities, you have access to the same set of operational tools you use now to track service delivery and quality (for example, support for BERT and loopback testing).

Network management options: With Cisco EPN Manager's integrated lifecycle management and standards-based northbound interfaces, you can easily integrate with your existing OSS/BSS applications. Across optical transport and Carrier Ethernet, Cisco EPN Manager provides the required comprehensive TDM and IP service lifecycle management, including fault, configuration, performance monitoring, and provisioning. Cisco EPN Manager is also easy to use, incorporating simplified workflows and operations-based tasks that align with existing user roles, so no new hires or skillsets are required.

Flexible implementation: You can fully migrate to the Cisco solution by using a hybrid approach, replacing aging hardware as needed or by doing a more comprehensive changeover. The solution can be deployed and integrated with no effect on end customers or existing services.

Requirements Checklist for the Next Generation Transport Network

- **Minimize effects on legacy infrastructure services,** including maintaining existing service SLAs and using existing customer premises equipment (CPE) to decrease customer churn rates.
- **Launch new service offerings,** including new IP and Carrier Ethernet services.
- **Reduce OpEx requirements,** including costs for space, power, and maintenance as well as the cost per bit to deliver traffic through the integration of next-generation technology.
- **Support SLAs,** including the industry standard 99.998 percent SLAs for uptime, and 50ms timing for voice, and the use of scalable technology such as DWDM to support an anticipated 50 percent annual bandwidth growth rate.
- **Reduce CapEx while maintaining support for critical network management,** including business-critical operational features (for example, bit error rate testing (BERT) and loopback testing) whose local and remote controlled test equipment can be eliminated; integration with existing OSS/BSS systems; and comprehensive TDM and IP service lifecycle management.
- **Support a simple, robust implementation** through the automation of the solution deployment, thereby minimizing effects on end customers, existing services, and maintenance windows.

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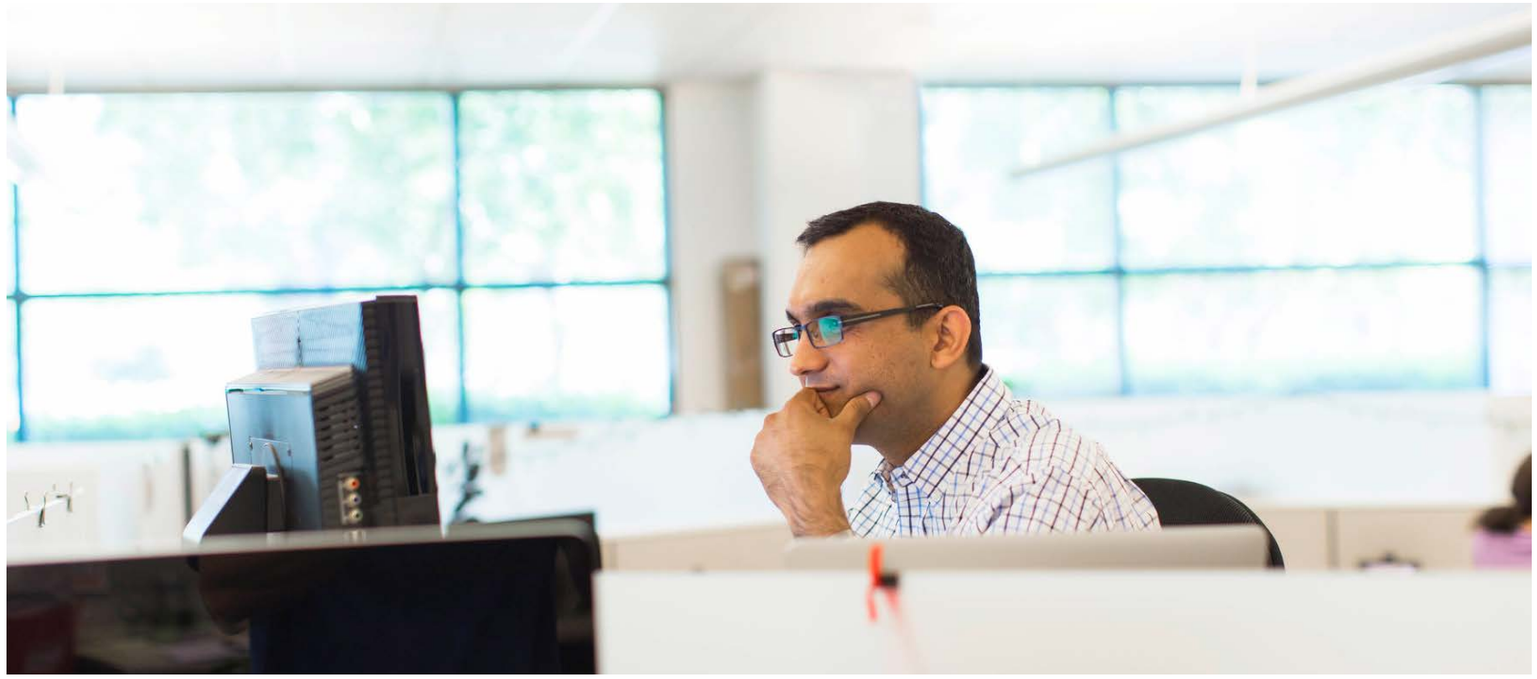
Case Study: Major Service Provider Retools Transport Network for Next-Generation Services with Packet Optical over CEM



Issues with Scaling and Speed Push Overhaul of Optical Transport Network

A large U.S. service provider couldn't efficiently scale its transport network using existing technology to meet new business demands. Additionally, IT managers wanted to deploy services more quickly and more efficiently using next-generation solutions and to introduce 100GB technology to the metro network.

Cisco demonstrated to the company's management that the provider could not efficiently scale the network by adding more hardware layers. Instead, Cisco transport specialists advised reducing the equipment footprint in the central office to save on power, cooling, and cost per square foot. The aging hardware included 25-year-old ADMs and DCSs. In their place, the Cisco Network Convergence System (NCS) 4200, 4000, and 2000 platforms were proposed. They feature Cisco's high-density CEM technology for the transport of legacy TDM services combined with the use of Cisco EPN Manager for a multilayer, full-service approach to network management that includes Ethernet and IP/MPLS traffic.

Developing a Solution Based on Real-World Data

The Cisco account team modeled one large metropolitan market to demonstrate the solution's potential cost efficiency. Ten racks of new Cisco gear would replace 90 racks of old equipment from multiple vendors in the central office. The savings? Hundreds of millions of dollars in OpEx per year from the CEM approach, all easily managed by one solution, Cisco EPN Manager.

After the contract was awarded, the scope was increased to include access aggregation, Layer 2 aggregation, and the Layer 3 edge. The provider can now manage its network with a single tool, Cisco EPN Manager, instead of multiple network management systems and element management systems (NMSs/EMSs), from Layer 1 at the metro core through Layer 2 access device and aggregation, all the way to Layer 3 network interface devices (NIDs) at the service edge.

The Benefits to the Customer

The provider uses CEM to package old SONET-based TDM circuits as IP packets and send them through the IP network at 1/10 the cost. Removal of the legacy transport equipment reduced costs for power and cooling by 90 percent. With Cisco EPN Manager, the provider has a multilayer view of its network using a single tool. The provider was also able to stop using the aging, limited, and static OSMINE for alarming and provisioning. OSMINE is unable to recognize or manage advanced hardware functionality. Cisco EPN Manager can, including CDC ROADMs.

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Cisco Services

Experience and Competency Unmatched in the Industry

To plan, build, and manage a transport network migration project, service providers need the help of a professional services organization experienced in IP optical convergence. Cisco Services have the competencies required. Our breadth of IP optical convergence experience and competency is unmatched in the industry.

As your partner, Cisco Services help you to plan, build, and manage this technology convergence, reducing cost, risk, network complexity, and time to adoption of new revenue-generating services. We help you realize the full value of your IP optical network, IT, and communications investments more quickly and successfully harness the converged network as a powerful business platform.

Network Convergence Can Be Different for Each Network Operator

The flexibility to understand and achieve service provider business goals is paramount. Our services help evolve networks to support business continuity and growth, increase operational efficiency, reduce costs, enable a more reliable customer experience, and mitigate risk. Cisco Services uniquely deliver innovative solutions, unmatched expertise, and smart service capabilities using a collaborative partner approach.

Our intellectual capital tools and extensive experience and expertise set Cisco Services apart from the competition. We have delivered successful plan, build, and manage services to all types of service providers around the world. We have five evolved programmable network (EPN) Experience Centers–U.S., U.K., India, Israel, and Japan–(including labs) for validation of customer-unique IP optical convergent network designs.

You can trust the success of your network operations to the worldwide leader in networking services and solutions.

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Summary and Benefits

A Proven and Standards-Based Approach to Next-Generation Transport

CEM and pseudowires are established technologies associated with multiple industry standards. And we've applied 20 years of experience in MPLS traffic engineering for the control plane. The Cisco Network Transport Modernization solution combines these and many other technologies together with powerful and versatile platforms and a unified tool for NMS/EMS. You're able to simplify your transport network while integrating both TDM and IP/MPLS packet traffic together. Nothing else quite like it is available on the market. Modernize easily and painlessly: You can modernize your transport network without service disruption or changing customer CPE. The new packet optical network performs like your TDM network, with a committed burst rate, path-level protection, 50ms resiliency, and other TDM-like attributes.

Get the scalability you need for the future: Your network will be able to scale like never before, to more than 12 terabytes in service. 100GB client connections for aggregated traffic will keep your customers more than satisfied. You'll be able to meet the annual 50 percent bandwidth growth that is forecasted through the use of highly scalable MPLS and DWDM technology.

Enjoy incredible OpEx savings from high-density CEM: According to our estimates, you'll save 90 percent from the elimination of DCS and ADMs and reductions in energy and space in your central office. Complexity is reduced through the point-and-click GUI. Cost per bit can be reduced by as much as 50 percent through the use of CEM and MPLS together with the OTN.

Future-proof instead of temporarily fix: Why spend money on legacy platforms and technologies that are essentially a technology dead end? Cisco platforms and CEM can be used to introduce greater network automation and the digitization of businesses. The same network can be used to deliver metro Ethernet and Layer 3 VPN services, too. Ultimately, the Cisco Transport Network Modernization solution allows you to migrate to a full IP transport network whenever you're ready.

Next Steps

For more information about the Cisco Transport Network Modernization solution, visit http://www.cisco.com/c/en/us/products/optical-networking/network-convergence-system-4200-series/index.html.

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