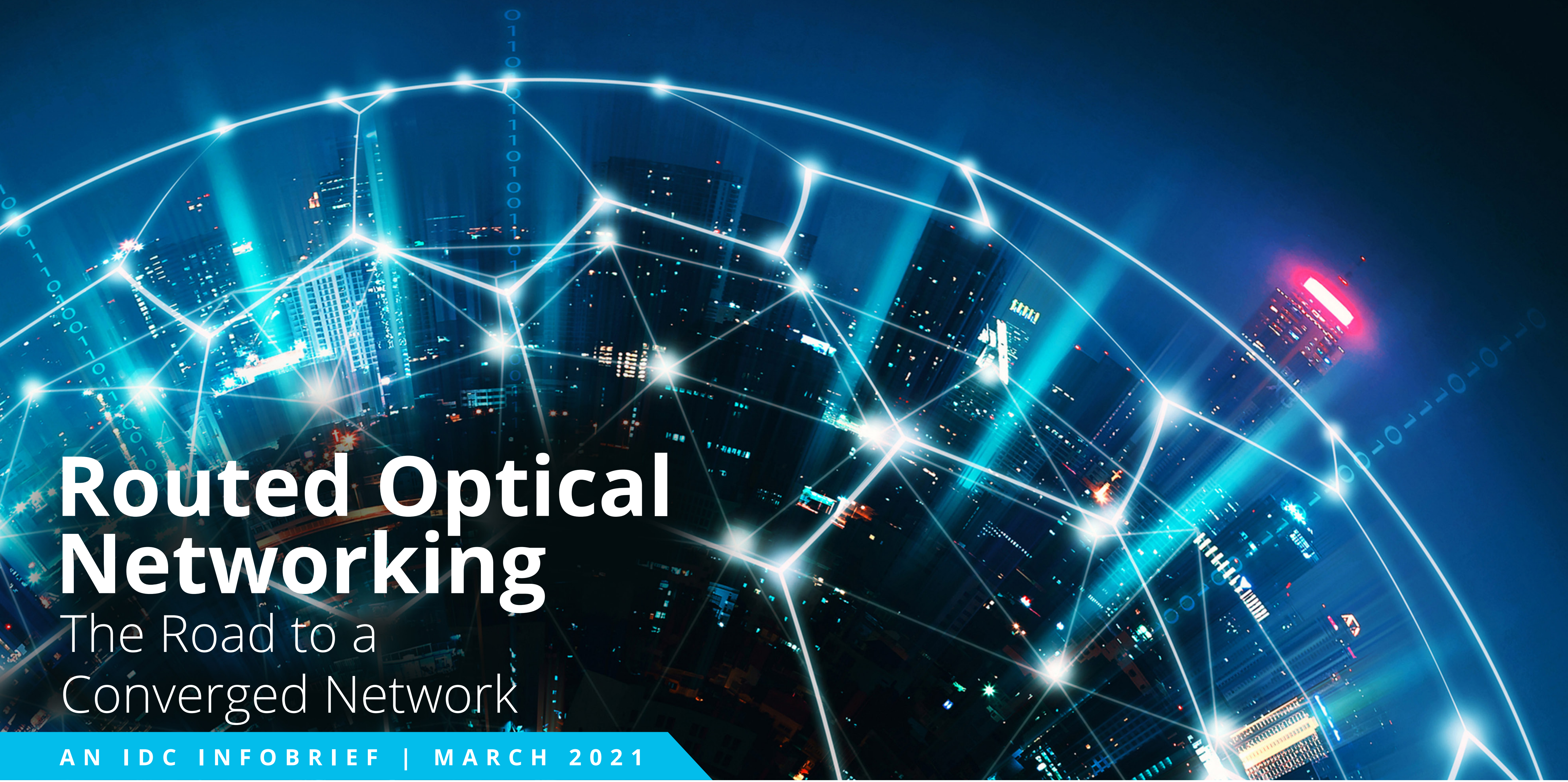

Routed Optical Networking

The Road to a Converged Network

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IDC ANALYZE THE FUTURE

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Executive summary

Service providers (SPs) have started to transform their networks into 5G transport architectures to address the growing traffic requirements on their networks. However, this is quite a complex journey as the layered and siloed nature of network infrastructure, along with multi-layered resiliency schemes, often results in poor utilization and monetization of network resources.

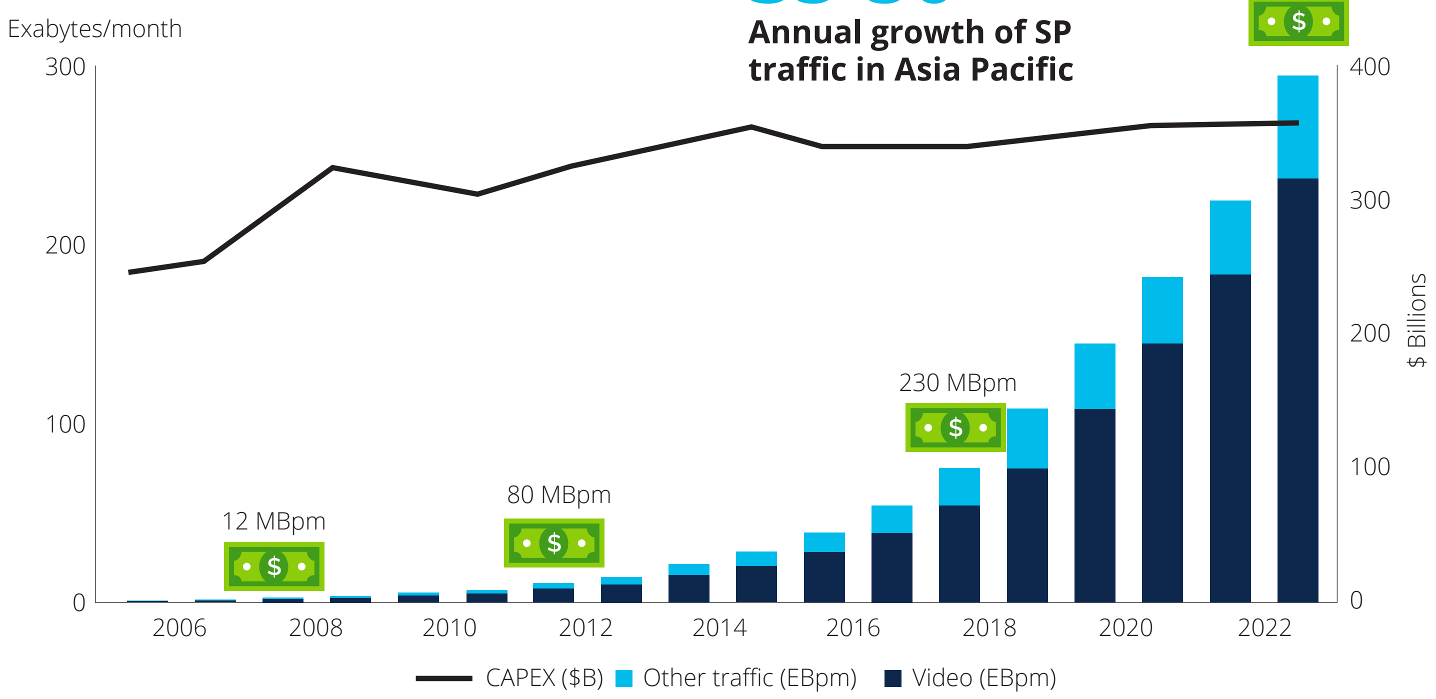
The legacy network architecture also leads to complex management and manual intervention at multiple levels, posing challenges in implementing end-to-end closed-loop automation.

Complex transformations like these require tightly-integrated networks that can scale with the future demands of high bandwidth including video streaming, low latency, and coverage densification. The routed optical networking solution can enable scale by converging mobile and fixed, voice and private line traffic onto a single converged internet protocol (IP) and optical network.

This IDC InfoBrief takes a closer look at the SP challenges, and the promise and motivations for routed optical networking.

35-50%

Annual growth of SP traffic in Asia Pacific



Source: Cisco Visual Networking Index 2020

Converged IP and optical architecture will enable total cost of ownership (TCO) savings of up to 45%

SPs are transforming their transport networks to address traffic growth

SPs understand that they must transform their transport networks to prepare for the 5G era.

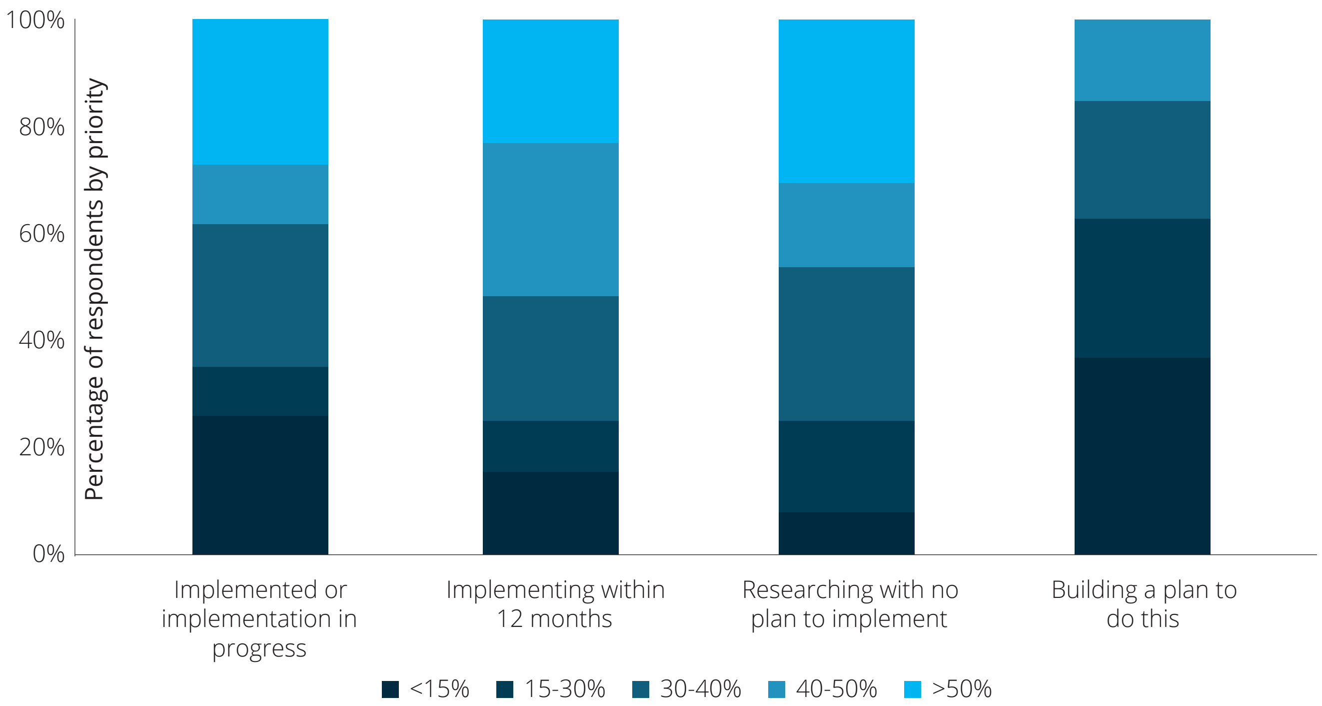
In IDC's 2020 Carrier Operations Transformation Survey, in response to what is affecting their business strategy, 80% of communications service providers (CSPs) in Asia/Pacific including Japan (APJ) cited increasing speed of innovation and 65% pointed to changing customer behavior.

The transport network defines overall customer experience and must be aligned with the CSP's digital transformation (DX) journey.

60% of CSPs surveyed in APJ have indicated they have optical transformation/upgrade projects underway.

Optical transport network performance/capacity upgrades

Q Please assess your technical and operational readiness to deliver the following services in support of your communications offerings.



Source: IDC 2020 APJ Carrier Operations Transformation Survey, N=280

Traffic volume and density will continue to increase

SPs have been challenged by traffic growth from mobile and fixed broadband users but in the next several years, the Internet of Things (IoT), including video-centric IoT, will also become an important driver of traffic growth.

5G will enable massive IoT and 4K video

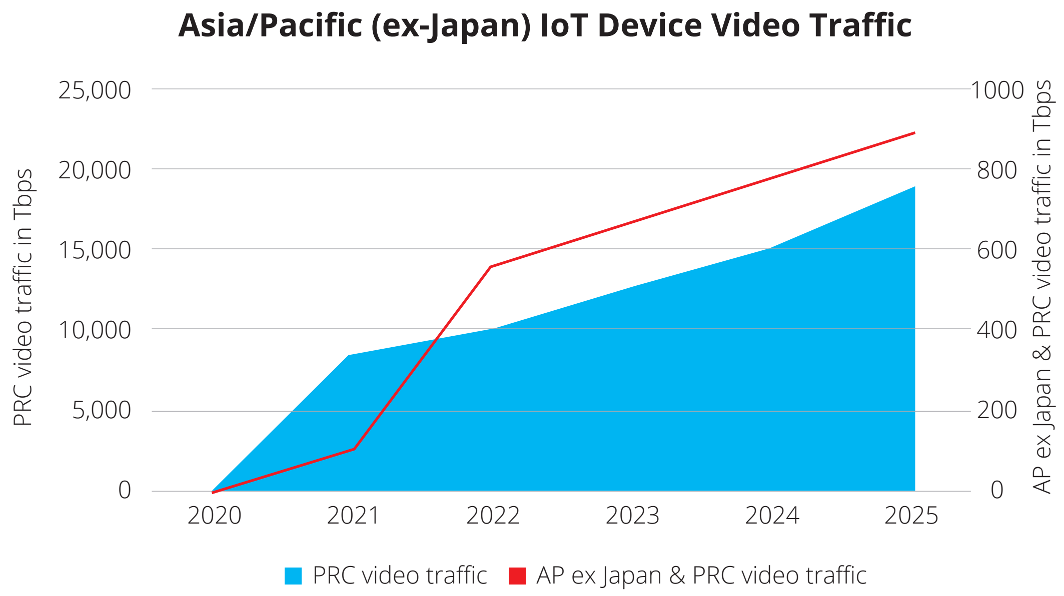
IDC forecasts that by 2023, there will be over 1 billion 5G connections globally. 5G sub-6 GHz commercial services have begun in a number of markets including Australia, South Korea, U.S., U.K., the People's Republic of China (PRC), Hong Kong, Saudi Arabia, and continental Europe. Japan launched mmWave services in Q4, 2020, and South Korea, Singapore, Hong Kong, and Russia are expected to go live in 2021 with mmWave. The PRC is expected to come onboard in 2022 once spectrum is allocated.

Cellular network becoming denser

Today's 4G markets are seeing average monthly data usage of 8-18 GBytes/month. The 5G 3GPP specification aims to deliver on average 100 Mbps service to users. 5G C-Band basestations (BTS) and mmWave 5G BTS are already delivering throughputs of up to 3.0 Gbps@100 MHz channel and 15 Gbps@400 MHz channel, respectively.

Fixed broadband and 5G fixed wireless access (FWA) will continue to grow

Fixed broadband networks are seeing homes consuming 100-300+ GBytes/month, increasing at a compound annual growth rate (CAGR) of 20-25%.



Note: 1 Mbps = 324 Gigabytes/month | 1 Gbps = 324 Terabytes/month | 1 Tbps = 324 Petabytes/month

5G will place tremendous stress on current transport network infrastructure, which is already very complex and more often than not was built in an incremental, piecemeal fashion.

SPs will struggle to maintain excellent service quality for both broadband and mobile broadband services. IDC's estimate puts the growth in traffic demand from 5G (and fiber broadband access) to 10X-15X, or 25-31% compound annual growth rate (CAGR) in the next decade.

Source: IDC IoT & Traffic Model, 2020

Pain points for operators

Today’s networks prevent economical scaling and expansion and are not well suited for automation.

Currently, the architectures of most SPs have these **pain points**:

Lack of scalability. Networks are often expanded in incremental fashion by adding network infrastructure (high capital expenditure, or CAPEX), resulting in highly-complex (operating expenditure, or OPEX, intensive) networks.

Complexity and cost. The networks comprise multi-layered and siloed infrastructure which require traffic hand-off between networking layers.

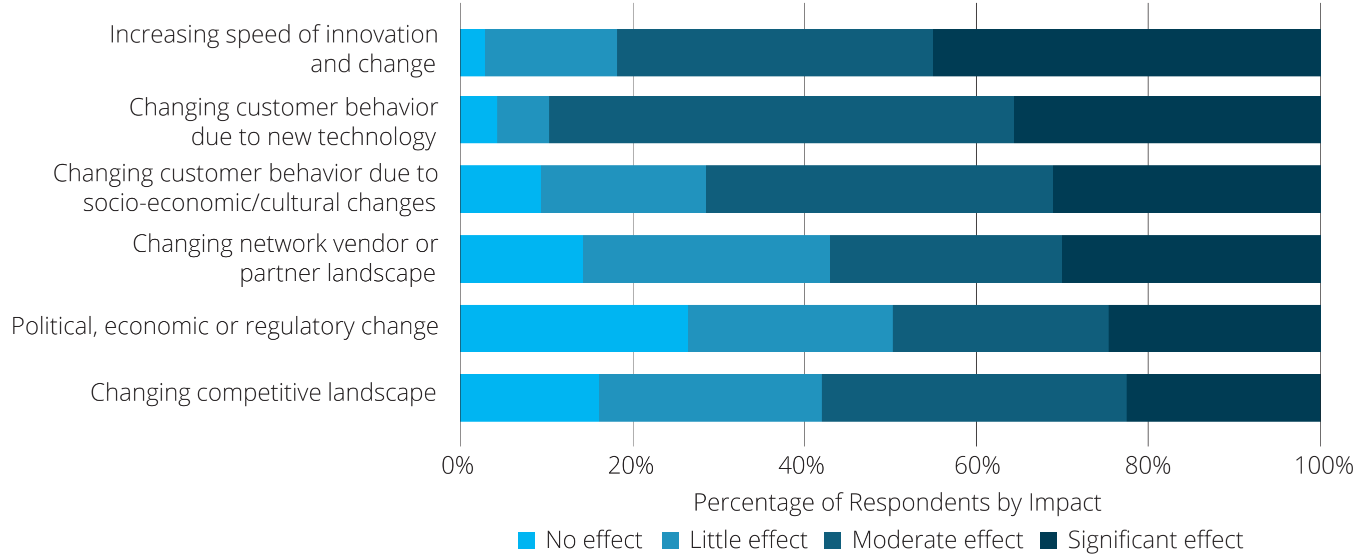
Resiliency schemes are overlapping and costly. Resiliency in each networking layer is often overlapping and redundant, resulting in higher costs and poor network resource utilization (poor utilization efficiency).

High topological complexity. This is due to multiple overlapping and independent switching points, control, and management planes associated with each network layer.

Manual service stitching. Layered and siloed architecture which requires manual service stitching across network domains, posing challenges to end-to-end closed-loop automation required for automated operations (remediation) and shorter service lead times.

Operators are being driven by multiple forces in the market

Q Overall, how much are the following external forces affecting your company and its strategy at the moment?



Drawback of legacy transport architecture

- Private-line services were a challenge that could only be addressed with dedicated resources.
- Bi-directional, deterministic services could only be provided via a separate network layer.
- Operations administration and maintenance (OAM) was done at each network layer perspective.
- Service level agreements (SLAs) were based on network layers rather than actual service availability.
- Inability to distribute bandwidth flexibly for better efficiency across service types in the optical plane.

Source: IDC 2020 Worldwide Carrier Operations Transformation Survey, N=280

Today's networks are layered, siloed and complex making automation/management/scaling difficult

Legacy networks maintain separate layers for optical transmission and IP routing.

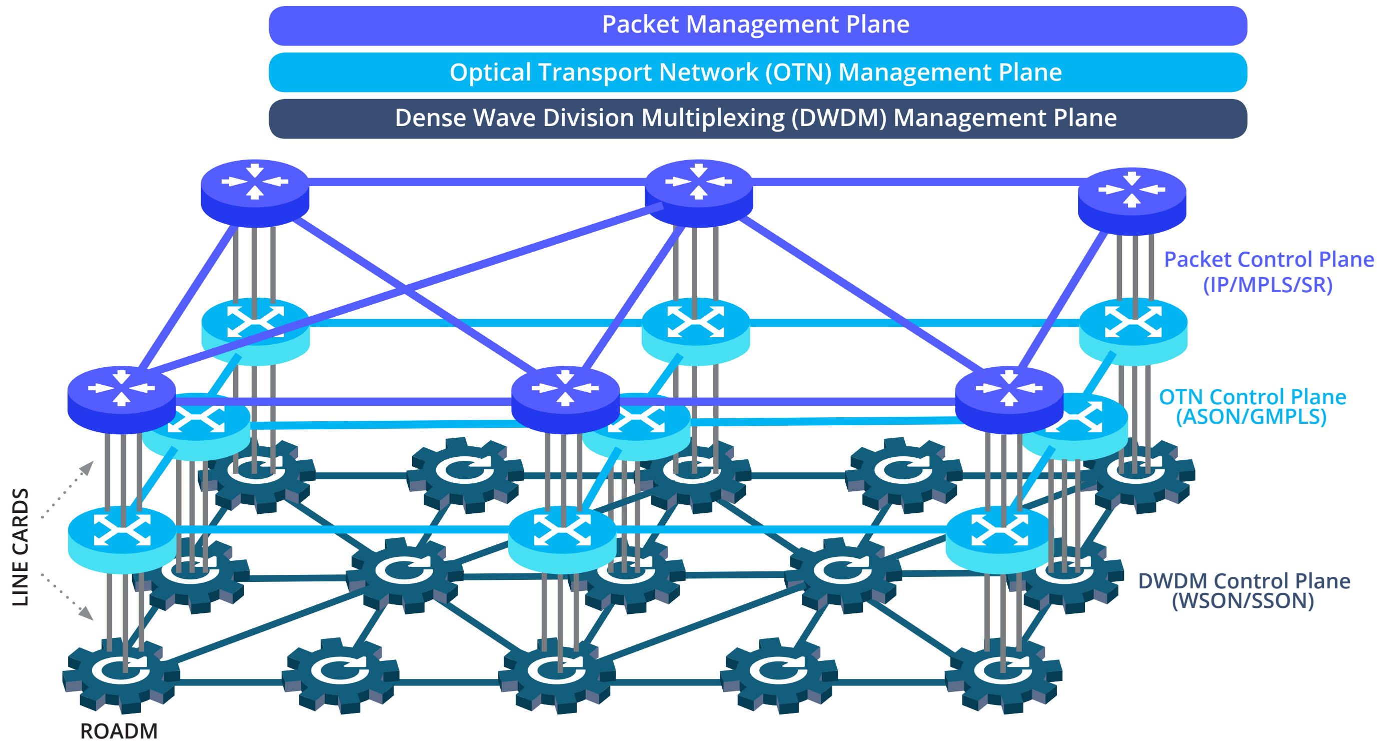
SP networks are multilayered and siloed

Traditional network architectures comprised networking layers that relied on line cards for service hand-off between the layers. Services terminate at different layers of the network. Each layer provides redundant functions, management, and control. This kind of layered architecture is highly inefficient as it consumes too much line card CAPEX resources and relies on manual operation for service hand-off between the layers.

Control and management

Moreover, each networking layer has its own control and management plane associated with it which operates independently from each other.

This complexity negatively impacts service assurance, fault correlation, path optimization in terms of network utilization, as well as network planning and optimization. These complexities present challenges to SPs' aspirations towards achieving service-driven end-to-end, closed-loop automation across the entire network infrastructure.



Total cost of ownership (TCO)

TCO associated with legacy network architecture is prohibitively high and will not allow SPs to scale their network to meet the capacity demands of IP services in a cost-efficient manner.

Many SPs today are focused on the layer of the network to deliver a service rather than on the service itself. The focus on networking layers is largely driven by the assumption that specific SLA targets could only be achieved in specific networking layers where transport infrastructure could only leverage time division multiplexing (TDM) services that required a distinct independent network silo/overlay.

The solution is to build a converged optical + IP network

Coherent pluggable module. As router port densities increase, the CAPEX spend transitions from the line card ports to the pluggable optics.

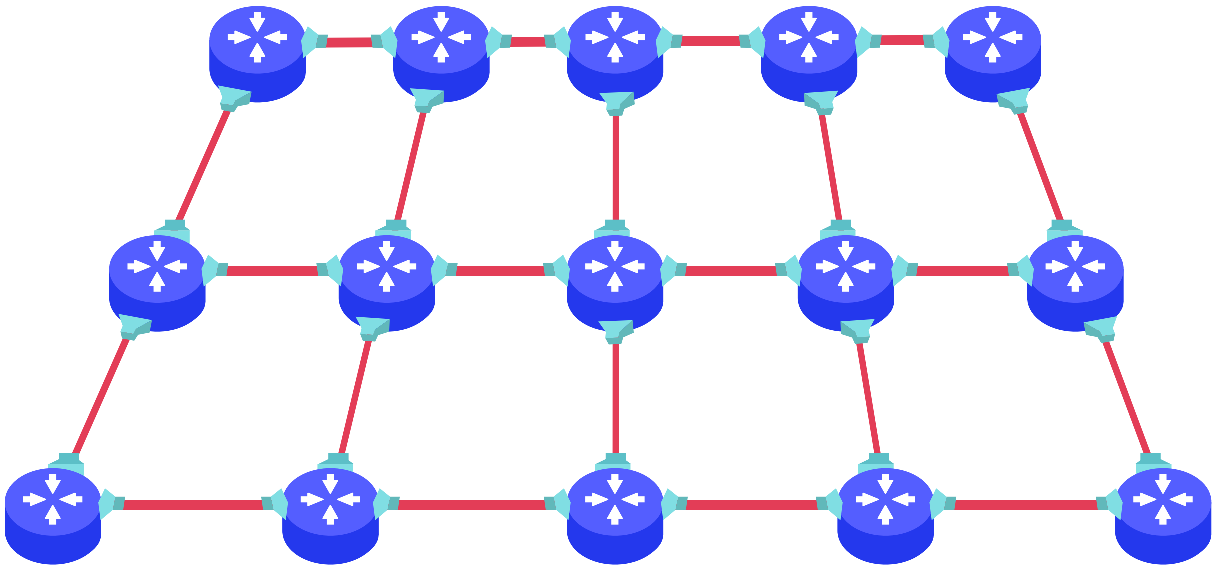
Line rate scaling is achieved with 400GE line rate. The critical enabler for the scale envisioned for the future CSP network is the 400GbE line rate.

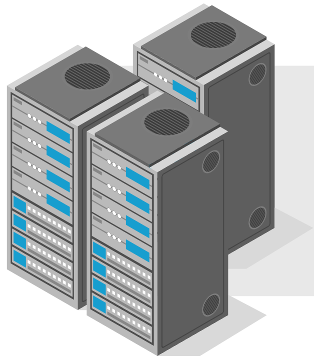
Multi-vendor, standardized and preserves port density. Quad small form-factor pluggable (QSFP) double-density (DD) module allows interoperability for easier adoption and benefits of scale. The compact size of QSFP-DD pluggable module offers 400G line rate scalability while preserving the port size in the router.

5G radio access network (RAN) will impose transport demands and will migrate from long-haul to metro domains and applications.

400G QSFP-DD optical modules go the distance. QSFP-DD can provide transport to the mobile edge (20 km), regional datacenters (40 km) and central datacenters (80 km and and above). 400GE pluggable coherent optics will become ubiquitous in networks by 2022. And with OpenZR+, distances of 1500km are possible.

Hop-by-hop (H2H) is the future of transport. H2H routed network architecture will replace traditional multi-layered “hollow-core” architecture.





H2H architecture shortens the route path distance between endpoints. H2H allows true network capacity optimization with network simplification by collapsing network layers and eliminating the complexity and redundant nature of multi-layer networks.

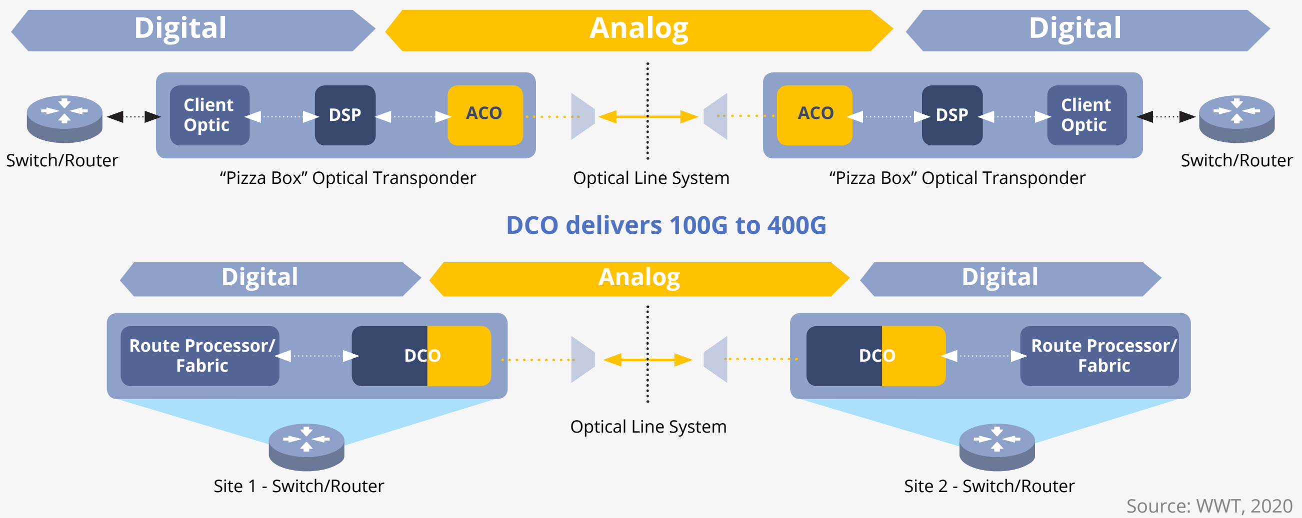
Coherent optical modules are key to the economics of convergence

Why is the transport economics important? Better utilization of network resources and scalability.

A coherent optical module refers to a typically hot-pluggable coherent optical transceiver that uses coherent modulation and is normally used in high-bandwidth data communications applications.

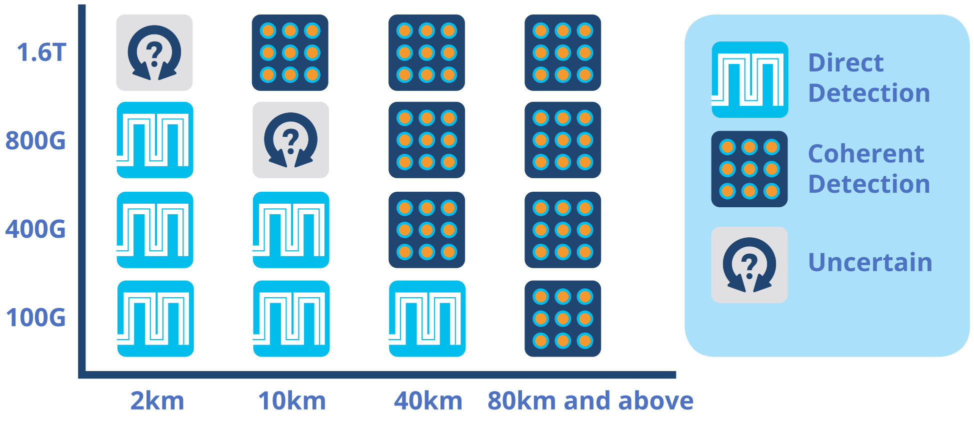
Optical modules characteristically have an electrical interface on the side that connects to the inside of the system, and an optical interface on the side that connects to the outside world through a fiber optic cable.

Coherent optical modules plug directly into the router line cards.



Source: WWT, 2020

Coherent detection moving deeper into the network: optical internet working forum zero return (OIF ZR) specification for <120km and OpenZR+ for >120 km reach

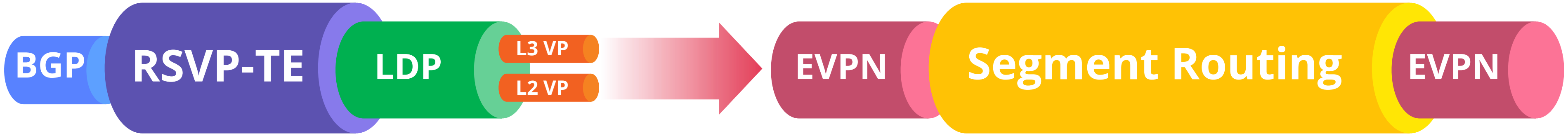


Source: Cisco "5G Transport" White Paper, 2020

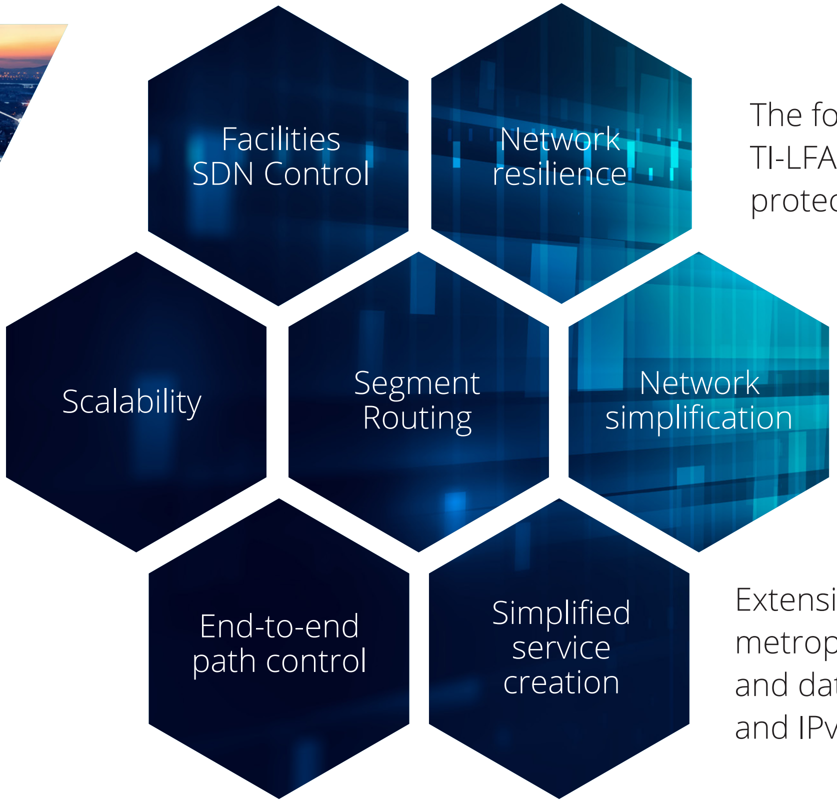
The optical transceiver is one of the most important elements in datacenters. Currently, QSFP28 transceiver module is the leading product in the market that supports 100 gigabit Ethernet applications. However, the market continues to evolve with the emergence of new bandwidth-hungry applications such as 4K HD video, webcast, virtual reality (VR) and cloud computing. The 400G QSFP-DD optical module is being positioned to efficiently address this need for higher capacity in the metro.

Segment routing simplifies the network

Segment routing (SR) can be leveraged to support both packet and TDM VPN services overlays. This enables a single network layer for switching and aggregation of all manner of services. SR is a key enabler for a simplified and converged transport infrastructure for all SP services.



Software-defined network (SDN) can be used to centralize optimization and effectively replaces RSVP-TE (resource reservation protocol traffic engineering) distributed path computation mechanism and lack of coordinated resource allocation capability. The SR-TE state information is maintained only on the head node, and the intermediate node does not need to maintain the status information, so that the SDN controller can scale easily.



The forwarder provides IGP convergence and TI-LFA (Topology-Independent Loop-Free Alternate) protection for distributed intelligence.

SR simplifies the existing MPLS network and makes full use of the MPLS forwarding mechanism, which is backwards compatible with the current MPLS network and facilitates the smooth evolution from the existing MPLS network to SDN.

Extensive deployment scenarios, including IP RAN, metropolitan area network (MAN), backbone network, and datacenter interconnect (DCI) to support both MPLS and IPv6 networks.

Essential guidance: roadmap to converged SDN transport

Bringing it all together

1

Upgrade 4G LTE sites to 10/25 Gbps for 5G and vRAN/edge nodes

2

Converge fixed and mobile access using aggregation edge

3

Replace transponders with integrated coherent optics at 100G/200G/400G and integrate OTN services using emulation

4

Simplify optical control plane with IP/SR and use advanced emulation to transport private/OTN services

5

Utilize TI-LFA built on SR to provide fast reroute protection to services for failure scenarios including link, node, and local shared risk link group (SRLG)

6

Assimilate ROADM functions within switching/aggregation functions in IP/SR network infrastructure

7

Implement converged SDN transport

- Unified capacity planning
- Unified path optimization
- Orchestration and assurance
- Unified EMS