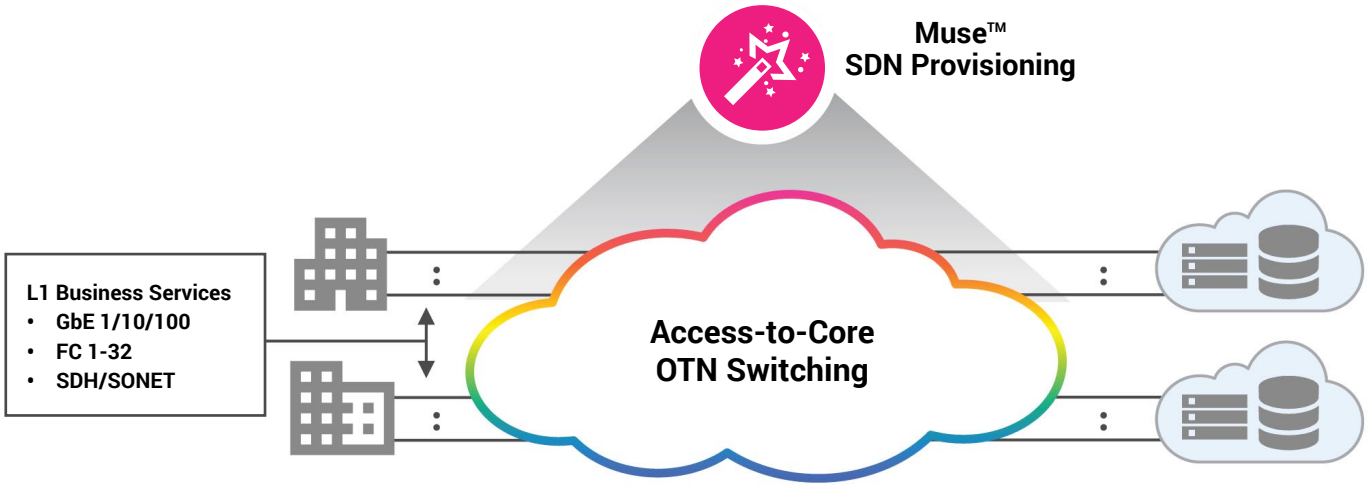
Rapid Provisioning of L1 Business Services

Obtaining a Competitive Advantage with Access-to-Core OTN Switching

Layer 1 transport services are a highly profitable offering that Service Providers can sell to enterprises. These services, which include Ethernet, Fibre Channel, and legacy SDH/SONET, provide connection to data centers and other corporate locations. However, it has always been a challenge to provision these services fast enough, due to the rigid, low-cost nature of optical access networks.

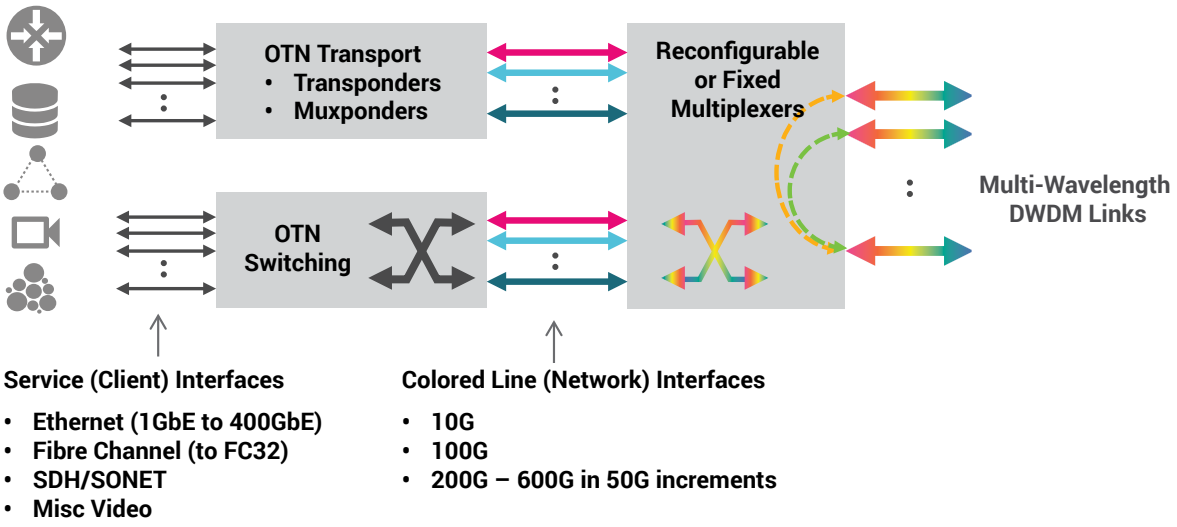
Apollo delivers an innovative and economical access-to-core OTN switching solution that enables SPs to provision these lucrative services rapidly, speeding up time to revenues and maintaining customer satisfaction. SPs can also guarantee service availability, by leveraging the dynamic restoration capabilities of end-to-end OTN switching.

Unique 'Access Optimized' OTN Switching	Point-and-Click Service Provisioning	Service Availability Guarantees	Value-Added Bandwidth-on-Demand



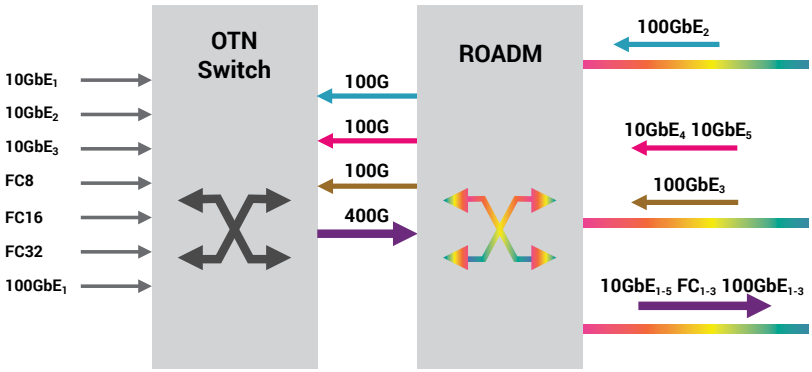
OTN Transport vs. OTN Switching

The goal of optical networks is to transport services like Ethernet, Fibre Channel, and SDH/SONET over wide geographic areas. It accomplishes this by mapping services onto high-power colored wavelengths for wide-area transport, and by combining colored wavelengths into single streams of light using DWDM.



The first step relies on the Optical Transport Network or OTN technology. This standard structure encapsulates one or more services into different sizes of optical containers and adds bits for error correction and operational monitoring. OTN then modulates the resulting bitstream of service payloads plus overhead onto a colored wavelength. In optical networking systems, OTN technology is implemented in two practical ways:

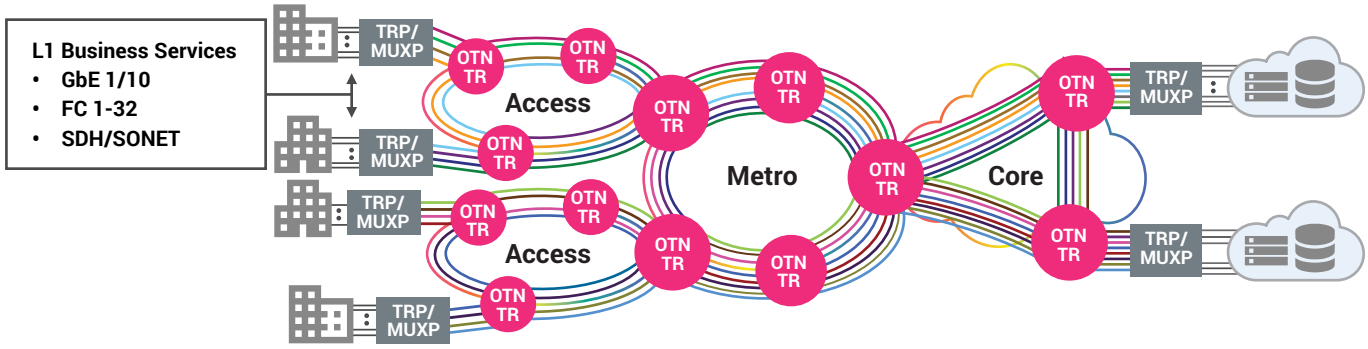
- **OTN Transport:** Transponders and muxponders map services directly onto wavelengths using an OTN mapper, in a tightly coupled manner. Transponders map a single service onto a single wavelength (at essentially the same rate, for example 100GbE maps onto a 100G wavelength), while muxponders combine and map several lower speed services onto a single wavelength.
- **OTN Switching:** An OTN switch maps services onto wavelengths – and interchanges services among wavelengths – in a highly flexible manner, via an OTN switching fabric. In the example shown, a mixture of seven services enter the node on gray wavelengths, and an additional four services enter on colored wavelengths via the ROADM. The OTN switch combines all these service onto a single 400G purple wavelength. Note, that the diagram shows only a single direction of what in actuality is a bi-directional system.



OTN switching's software-controllable flexibility brings multiple advantages for efficient wavelength use and dynamic service provisioning. However, it is usually more expensive to implement than OTN transport, due to additional optical-electrical-optical conversions and the cost of the switching matrices. Accordingly, OTN switching's primary use has been in the metro and core where economies of scale weigh in its favor. In this application note, we show how to extend OTN switching economically to the access network.

Baseline Approach Using OTN Transport

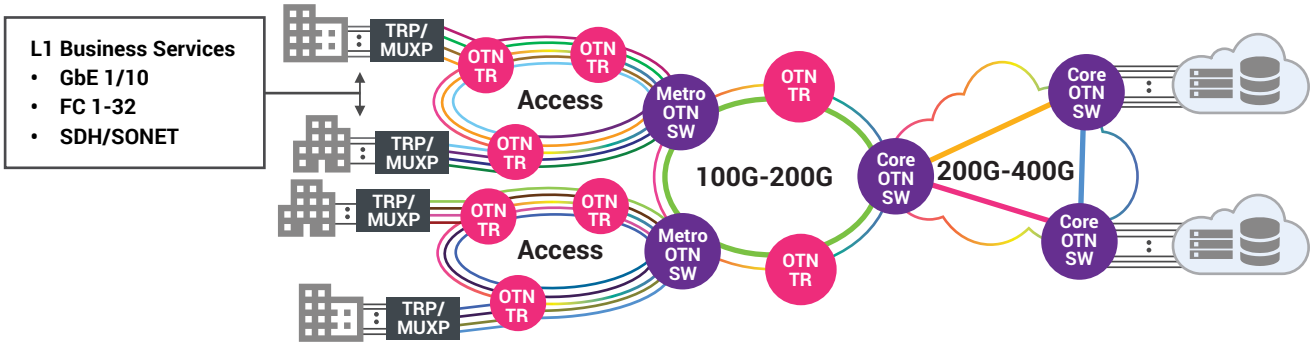
In a pure OTN transport approach, L1 business services (such as 1/10 Gigabit Ethernet, Fibre Channel for storage area networking, or legacy SDH/SONET) originate as gray wavelengths, are mapped onto transponders or muxponders, and then routed across the network using ROADMs.



In most cases, this baseline approach requires the addition of new wavelengths across the network for each new service. This has many downsides. End-to-end optical engineering for each new service adds operational expense, and unless the muxponders are already strategically located, new transport cards are needed, adding capital costs. This approach is very wasteful on wavelengths, creating high congestion in the metro and core. It requires a manual de-mux and re-mux of wavelengths as the only way to consolidate multiple services onto fewer wavelengths. Perhaps the largest drawback is a long provisioning cycle, which delays revenues and contributes to customer dissatisfaction.

Applying OTN Switching to Streamline the Metro and Core

Replacing OTN transport entities with OTN switches at key traffic exchange points in the metro and core, begins to address some of the limitations of the baseline approach. As previously stated, this has been the primary application of OTN switching to date, as its added benefits apply to many services and wavelengths, outweighing added costs. These benefits include:



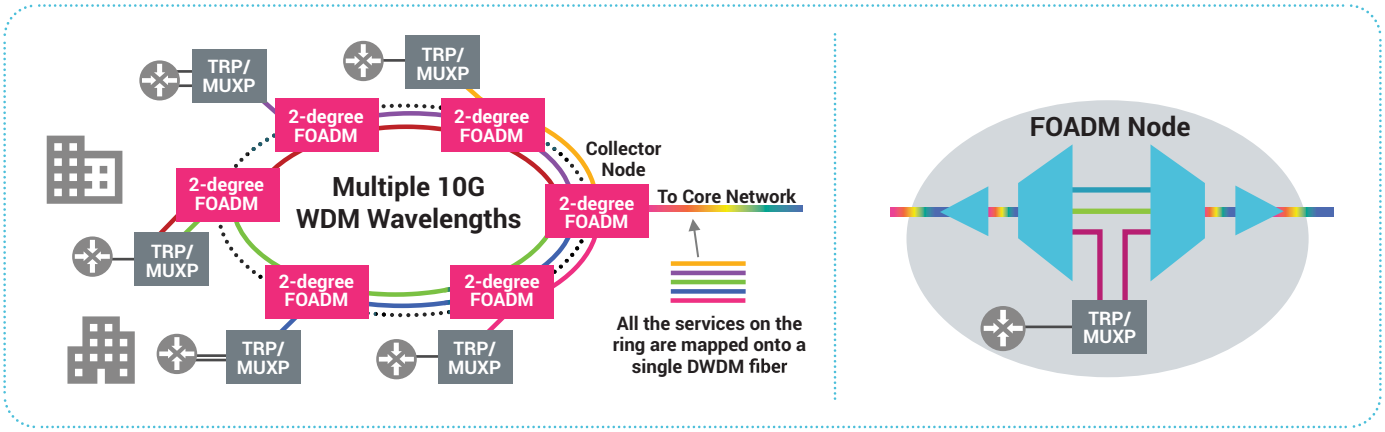
- **Functional separation:** Enables the use of transmission technologies in different parts of the network (i.e. access, metro, core) that are best suited to each part's unique topology and performance requirements. Moreover, these technologies can be deployed independently, evolving at their own pace.
- **Grooming:** All it takes is a few clicks to aggregate multiple lower-speed links into a smaller number of higher-speed links, ensuring no wasted bandwidth and providing a solution at a lower overall cost. Studies indicate that wavelength savings are on the order of 35%.

- **All-optical bypass traffic:** OTN switches operate seamlessly with ROADMs. Any wavelengths carrying services that are not dropped or groomed at a node can be "passed through" by the ROADM, entirely within the optical domain, reducing the number of interfaces on the OTN switch.
- **Dynamic restoration:** In case of link failures, OTN switches can re-route individual services on other working wavelengths. This can work in conjunction with ROADMs, to provide wavelength-level restoration and deliver the highest level of network robustness and service availability.

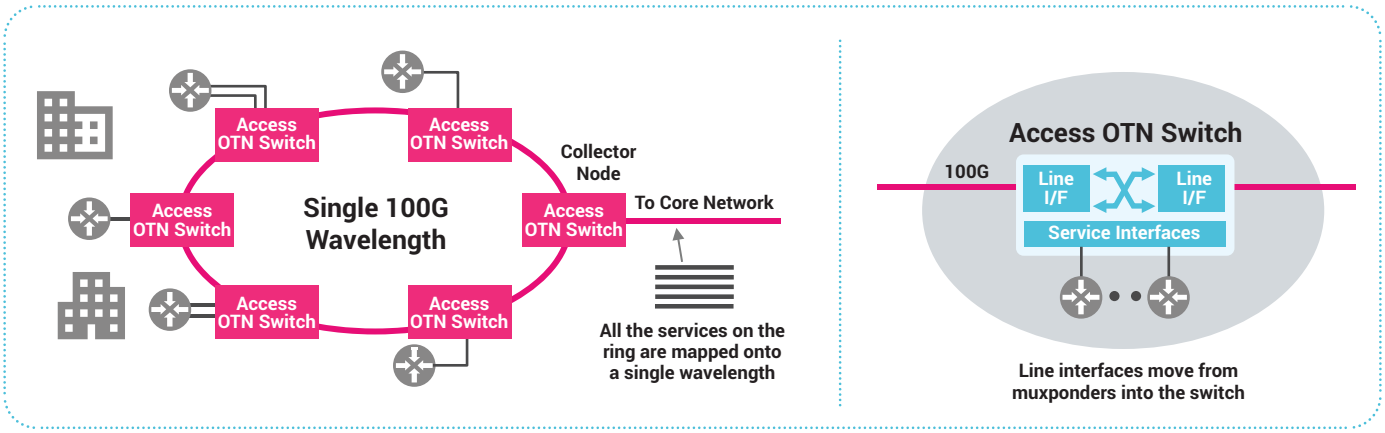
Yet, even with all these benefits, deploying OTN switches in the metro and core still does not solve the end-to-end L1 business service-provisioning challenge. To address this, we must find a way to extend OTN switching economically to the access networks.

Extending OTN Switching to the Access

Until now, engineering of optical access networks was focused on low cost. Transponders or muxponders map the services at a node onto individual 1G or 10G colored wavelengths. These wavelengths are then inserted manually into a WDM stream on the access ring using 2-degree fixed optical add-drop multiplexers (F-OADMs). This is a rigid process whereby every service requires design, the WDM ring requires amplification and dispersion compensation, and changes and responses to customer requests take too much time.

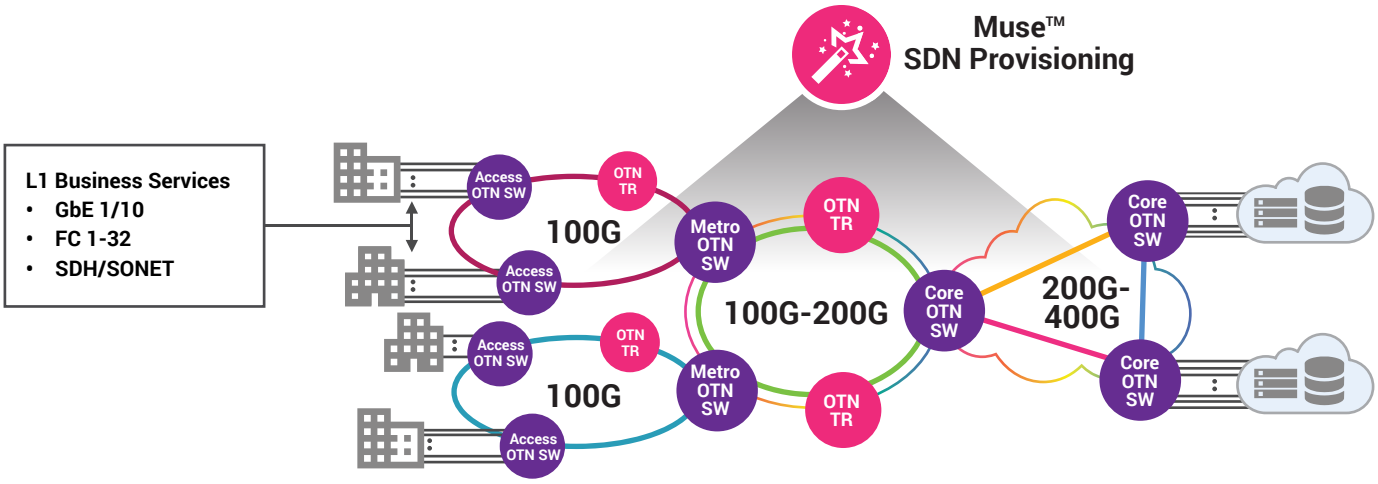


However, a new generation of economical Small Form Factor OTN switches, like the Apollo 9901X, is starting to change the equation, particularly for Layer 1 business services. These enable the ring to use a single 100G wavelength rather than a WDM fiber. Services connect to the OTN switches via low-cost gray interfaces, and are added to the ring traffic under software control.



This produces a flexible optical edge at the same cost as the traditional approach, with many benefits, including:

- **One-time network engineering:** A single wavelength for the access ring is engineered once, rather than engineering multiple wavelengths separately for each node.
- **Fast service provisioning:** Services physically plug into the OTN switches via simple gray wavelengths, and are provisioned with a few clicks. No additional network engineering is required. By working in conjunction with OTN switching in the metro and core, software-controlled end-to-end provisioning is made possible.
- **Easy changes:** Ongoing moves, changes, additions, and deletions of L1 services on the optical network are all software-controlled.
- **Value-added services:** By selecting appropriate features on the OTN switch service interfaces, Service Providers can offer value- added services to their business customers, like L1 optical encryption and bandwidth-on-demand.
- **Advanced protection schemes:** Various levels of service availability guarantees can be extended to business customers, by using different combinations of redundant links and dynamic service restoration via OTN switching.



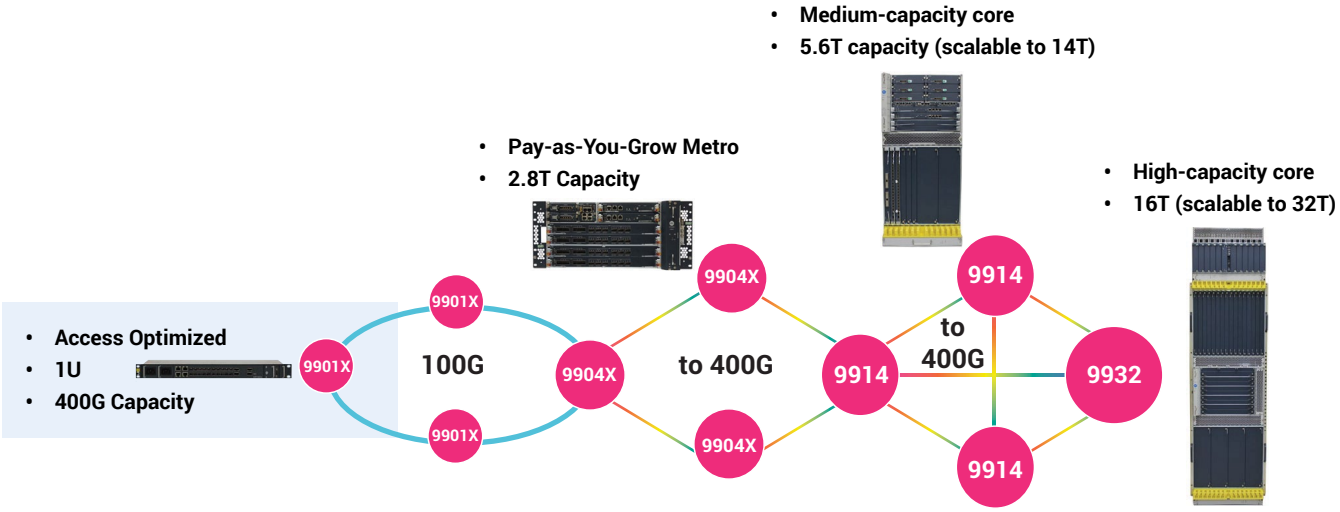
Apollo Access-to-Core OTN Switching Solution

The Apollo 9900 family of OTN switches makes it easy to deploy and obtain the full value from OTN switching solutions, especially rapid provisioning of L1 business services. Apollo 9900 works together with Apollo 9600 transport elements, including transponders, muxponders, and CDC-F ROADMs, for powerful and customized optical networking solutions. Muse lifecycle automation applications deliver speedy service provisioning, predictive maintenance, and dynamic restoration.

Moreover, Apollo 9900 OTN switching has many distinctive capabilities:

- **Access-to-Core coverage:** Supplies the 'right-sized' switch for economical deployment anywhere in the network, from the access to the core. In particular, the family now premiers an innovative 9901X 'access optimized' OTN switch.
- **Complete set of Layer 1 service interfaces:** Aggregates and grooms all major types of service traffic, including Ethernet (1GbE, 10GbE, 40GbE, 100GbE), Fibre Channel (FC1- FC32), and SDH/SONET.
- **Integrated Layer 2 interfaces:** Transports MEF-compliant Ethernet packet services over the OTN domain to connect routers, with interface bandwidth provisioned dynamically, via ODUflex.

- **Full Switching Matrix Availability:** Makes the full capacity of each OTN switch available for all L1 and L2 services, surpassing some competitors that have limits for different configurations.
- **Evolvable line interfaces:** Uses a pluggables strategy to always support the most recent line interface technologies, including 400GZR/ZR+.
- **Open Control Interfaces:** Allows customers to exercise control through 3rd-party optical domain controllers, via standard Netconf/Yang northbound interfaces, as defined by the OpenROADM MSA.



Summary

In the past, the OTN switching business case has been primarily in metro and core networks, where it could maximize benefits across a large number of services and wavelengths. Apollo now extends OTN switching to access networks, enabling end-to-end applications including rapid provisioning of Layer 1 business services.

About Ribbon

Ribbon Communications (Nasdaq: RBBN) delivers communications software, IP and optical networking solutions to service providers, enterprises and critical infrastructure sectors globally. We engage deeply with our customers, helping them modernize their networks for improved competitive positioning and business outcomes in today's smart, always-on and data-hungry world. Our innovative, end-to-end solutions portfolio delivers unparalleled scale, performance, and agility, including core to edge software-centric solutions, cloud-native offers, leading-edge security and analytics tools, along with IP and optical networking solutions for 5G. We maintain a keen focus on our commitments to Environmental, Social and Governance (ESG) matters, offering an annual Sustainability Report to our stakeholders. To learn more about Ribbon visit rbbn.com.

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