Multi-stack MPLS

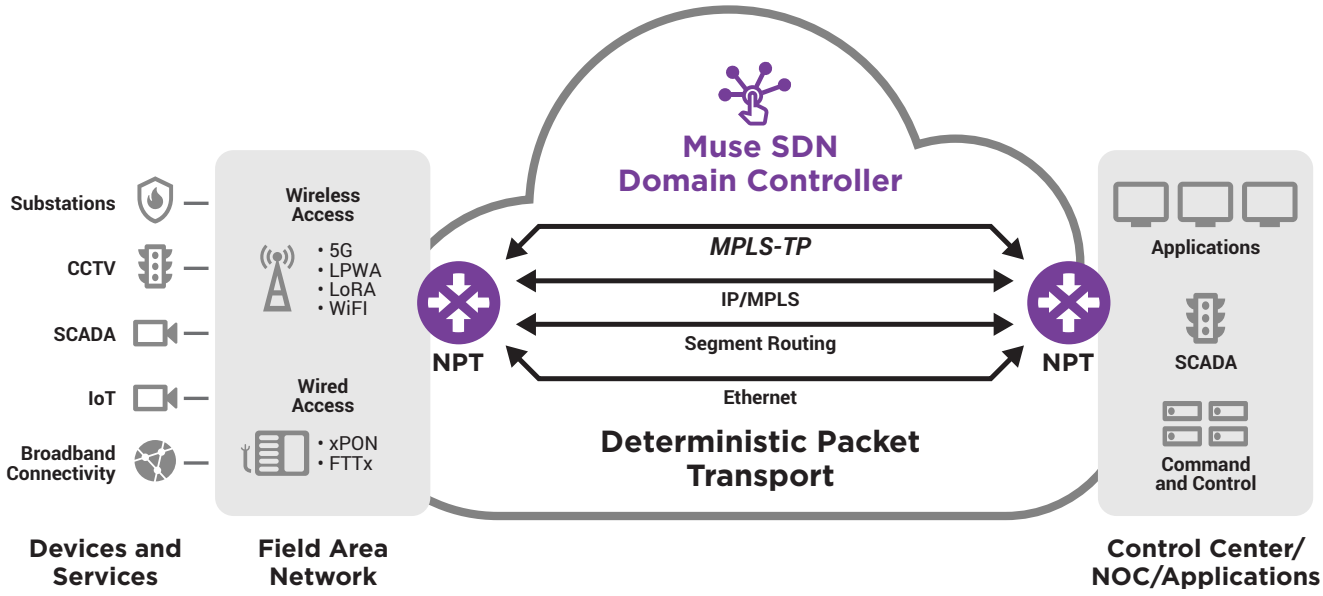
for Mission Critical Networks

Combining Static and Dynamic MPLS on Critical Infrastructure Applications

In the Critical Infrastructure (CI) market, Information Technology (IT) and Operational Technology (OT) applications have different transport requirements. The IT network runs non-mission-critical, IP-based applications that are optimized to run on IP/MPLS. However, the OT network requires static and deterministic behavior from the IP network to transport its mission-critical applications. MPLS-TP has been designed to provide these capabilities. When operators are forced to use a single technology across the entire network, they must make compromises in terms of features, protection requirements, and performance.

Multi-Stack MPLS design allows operators to use the technology that best fits their operational needs on a per-application basis. This is achieved by providing MPLS-TP, IP/MPLS (including RSVP-TE and SR-TE) on the same network element with gateway functionality between the two.

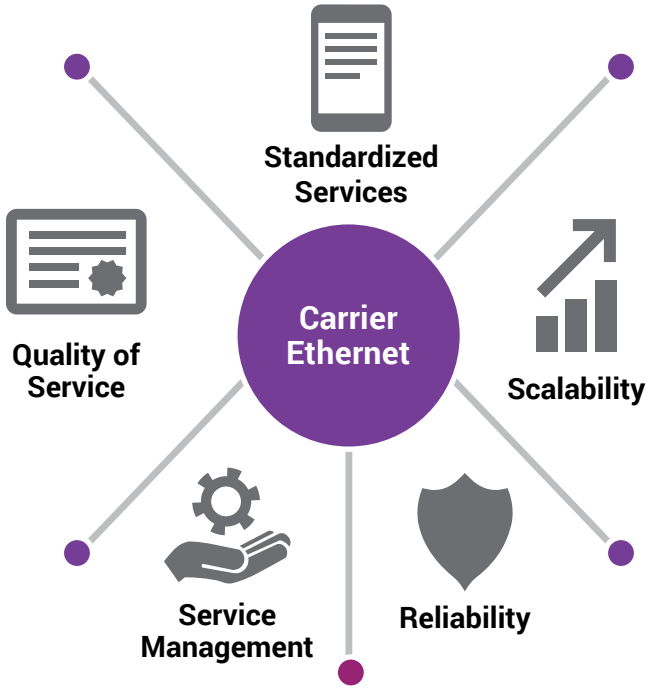
This paper discusses the differences between IP/MPLS and MPLS-TP and demonstrates the benefits and rationale of using both protocols on the same network element, while maintaining separate network domains, for greater security.



IP/MPLS for Dynamic IP Networks

Standardized by the IETF, IP/MPLS (Multi Protocol Label Switching) is a scalable, protocol-agnostic mechanism designed to carry circuit and packet traffic over virtual circuits, known as Label Switched Paths (LSPs). Functioning between the traditional OSI Layers 2 and 3, IP/MPLS makes packet forwarding decisions based on the contents of the label, without examining the packet itself.

IP/MPLS was originally developed to facilitate packet forwarding via label switching. Its attributes, like connection establishment, improved network resiliency, and OAM functions, help overcome native Ethernet transport gaps to achieve carrier-class Ethernet.



Standardized Services

IP/MPLS enables a full range of high-performance MEF-defined point-to-point (E-LINE), point-to-multipoint (E-TREE), and multipoint-to-multipoint (E-LAN) connectivity services. Legacy services, including SCADA and telemetry, are also supported through TDM pseudowires, providing circuit emulation in the MPLS network. The abundance of MPLS ensures interoperability in a multi-vendor network environment. The addition of multicast capabilities, combined with pseudowire support, provides an efficient IP CCTV connectivity solution. It also enables IP/MPLS deployment within the CI network core or backbone, while deploying MPLS-TP on the aggregation or distribution layer using the same platform.

Quality of Service (QoS)

IP/MPLS can transport all types of traffic with guaranteed QoS, per application, regardless of the encapsulated data protocol. LSPs facilitate the engineering of network traffic patterns without the need for routing tables. They also steer traffic flows from congested links to alternate links and control-specific traffic flow paths to guarantee fast resiliency. IP/MPLS also supports QoS parameters, such as frame delay, jitter, and packet loss. MPLS enables reservation of bandwidth for selected traffic and admission control.

Reliability

IP/MPLS has a variety of local- and path-protection mechanisms to help minimize LSP packet loss and ensure high-service reliability. IP/MPLS can distribute traffic across LSPs to provide superior load balancing. This reduces congestion and improves network predictability. MPLS Fast Reroute (FRR) enables service restoration with SONET/SDH-like protection times of less than 50ms, although it cannot be guaranteed in all network topologies and conditions.

Scalability

IP/MPLS supports a high number of service instances by layering multiple services onto each MPLS LSP. Bandwidth provisioning for each service is tailored to the particular needs of the customer at each site. MPLS-enabled services scale geographically because they can be provisioned over multiple MPLS-based carrier networks. New options, such as pseudowire switching, help scale Ethernet services over several networks.

Service Management

Service management is key in allowing critical infrastructure network operators to roll out, maintain, and troubleshoot their services in a cost-effective and timely manner. MPLS OAM tools complement the Ethernet link OAM (IEEE 802.3ah) and service management OAM (EEE 802.1ag and ITU-T Y.1731) tools to create a multilayer OAM solution. This is necessary to support network and application assurance. CI operators who are willing to deploy business services in order to evolve and become Utelcos (Utility Telecommunications Service Providers) will benefit from the service-awareness features and scalability available with IP/MPLS.

IP/MPLS as a Choice for Core and IT Networks

IP/MPLS streamlines L2 and L3 VPN service provisioning and provides QoS and OAM across core and IT networks. It optimizes services for different performance and user profiles and provides visibility and control of these services for large networks. These capabilities allow Core/IT network expansion across multiple network topologies like mesh, ring, hub, and star. CI operators will be able to virtualize services, converging the different services in the network, such as corporate voice and data, operational voice and video, SCADA and telemetry, and others - under a unified platform.

MPLS-TP for Mission Critical Applications

IP/MPLS provides carrier-class transport of IP services, whereas MPLS-TP (MPLS Transport Profile) enables MPLS to be used as the communications network for mission-critical operational technology (OT) in critical industries (CI).
The primary goal of MPLS-TP is to create a deterministic packet transport network (PTN) which offers the same level of determinism as traditional SDH/SONET networks. To accomplish this, MPLS-TP is built upon IP/MPLS but is specifically optimized to deliver deterministic packet transport. It incorporates both a subset and an extension of IP/MPLS features. Some of the complex functionalities of IP/MPLS, which are not necessary for deterministic packet transport, are disabled, while additional features have been introduced to ensure determinism.

Key benefits offered by MPLS-TP:

Deterministic Transport

MPLS-TP offers deterministic transport by utilizing bidirectional PseudoWires (PW) and Label Switching Paths (LSP), unlike the unidirectional PWs and LSPs used in IP/MPLS. This bidirectional approach ensures that traffic follows the same path in both directions, providing predictable and reliable packet transport and enabling precise packet synchronization.

Full Control

A centralized Network Management System (NMS) maintains a static configuration for mission-critical services. The centralized NMS also facilitates the use of intelligent planning and prediction tools, enhancing service awareness and enforcing strict Service Level Agreements (SLAs). The separation of the data plane from the control plane in MPLS-TP further enhances network resilience and security.

Transport-Class OAM

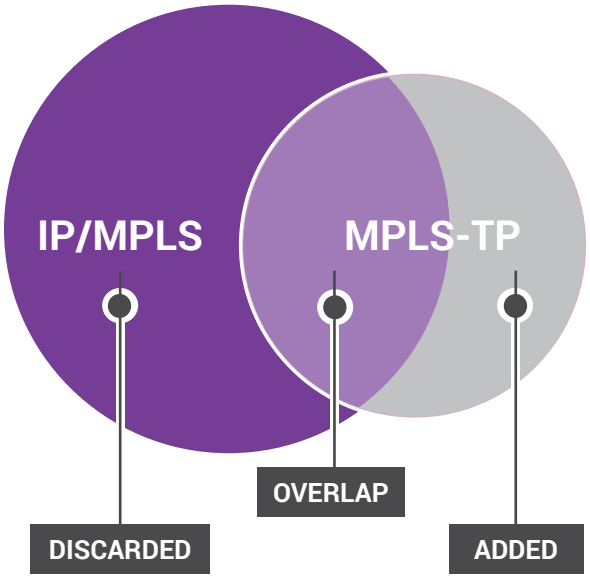
MPLS-TP supports comprehensive Operation, Administration, and Maintenance (OAM) functions, comparable to those found in traditional SDH/SONET networks. . These functions include advanced Fault Management, Performance Monitoring, and in-band PW/LSP/Section OAM levels. The OAM functions are integral to the MPLS-TP data plane and operate independently of the control plane.

Improved Resiliency

MPLS-TP ensures sub-50ms protection switching for all network topologies through predetermined alternative paths, regardless of the network status. For mission-critical applications such as SCADA and teleprotection, it is essential that the protective paths provide the same low latency, jitter, and round-trip delay as the primary path.

Lower Total Cost of Ownership (TCO)

The integration of IP/MPLS and MPLS-TP on a single platform reduces the Total Cost of Ownership (TCO) by enabling the efficient convergence of IT and OT services. This unified platform offers end-to-end visibility and control, thereby optimizing operational efficiency and cost-effectiveness.



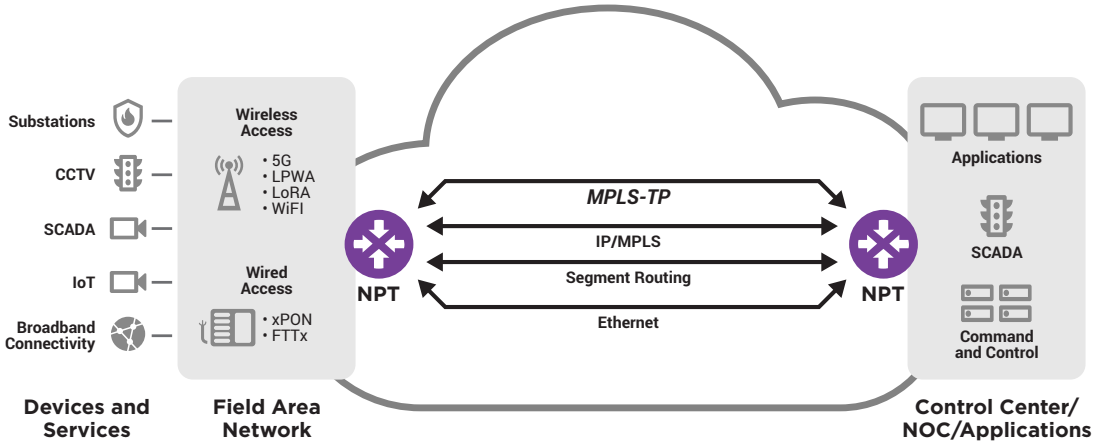
Multi-Stack MPLS – The Best of Both Worlds

MPLS-TP is tailored for mission-critical OT services requiring predictable performance. In contrast, IP/MPLS is better suited for core or backbone IT networks. Ribbon's innovative multi-stack MPLS approach efficiently supports both IP/MPLS and MPLS-TP.

The deterministic packet transport capabilities of MPLS-TP offer operators of mission-critical networks a reliable, proven technology to support their legacy OT services on a modern packet transport network. By migrating these legacy services, operators can confidently phase out their end-of-life SDH/SONET transport networks with minimal risk.

Multi-stack MPLS ensures seamless interoperability between IP/MPLS and MPLS-TP domains. This approach eradicates the need to choose between the two standards, making it straightforward and low-risk to achieve IT/OT convergence. Additionally, it paves the way for adopting new deterministic IP/MPLS techniques such as SR-TE, when they become suitable for mission-critical networks. It even provides the technology required for the critical industry to offer telco services.

In summary, Ribbon's multi-stack MPLS provides the best of both worlds by combining the strengths of IP/MPLS and MPLS-TP, facilitating a secure and efficient transition for modernizing network infrastructures.



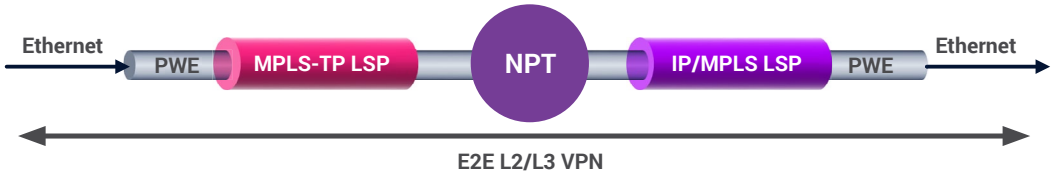
In addition to standard L3 VPNs (using E2E IP/MPLS) and L2 VPNs (either using static MPLS-TP or dynamic IP/MPLS), Multi-stack MPLS offers additional advantages, including:

Layer 3 VPN for Corporate LAN and Mobile Services

Multi-stack MPLS provides a unified management plane for end-to-end Layer 3 VPN services as they pass through the IP/MPLS and MPLS-TP domains. Layer 3 VPN services, such as corporate LAN and mobile backhaul, can be supported with the benefits of both MPLS-TP and IP/MPLS. The MPLS-TP domain provides proactive OAM and deterministic 1+1 resiliency. The IP/MPLS domain provides the benefits of dynamic forwarding in the backbone or core of the critical infrastructure network.

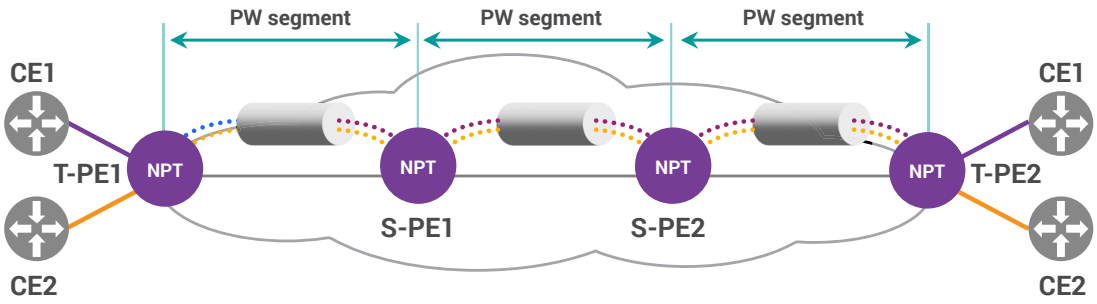
Streamlined Layer 2 Service Interworking

Multi-stack MPLS supports end-to-end Layer 2 VPN services and provides a unified management plane for service provisioning, visibility, and fault correlation, including OAM across the various network domains. Without Multi-stack MPLS capabilities, Critical Infrastructure operators would be forced deliver services across multiple technology domains, with each technology domain requiring different network platforms.



Establishing a Unified Packet Transport Network

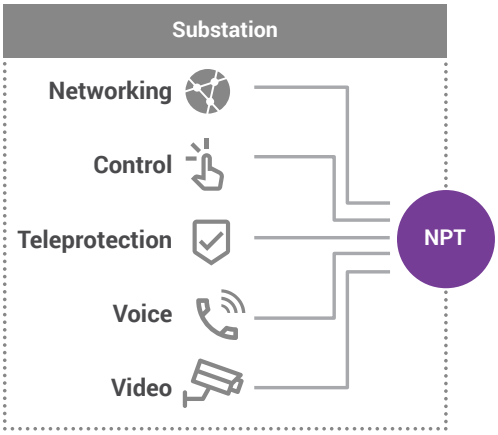
The primary goal for modernizing the communication network for critical infrastructures is to establish a unified packet transport network that supports all services. Ribbon's intelligent middle mile solution for Critical Infrastructures makes this a reality by leveraging multi-stack MPLS and the Muse SDN domain controller.



Enhanced Control

Multi-stack MPLS enables Critical Infrastructure (CI) networks to be partitioned into multiple segments through multi-segment pseudowires. This segmentation facilitates robust large-scale control while preserving end-to-end service integrity. By segregating services, each can be monitored with dedicated tools and settings. The integration of end-to-end management with advanced SDN tools grants CI network operators enhanced real-time visibility over all services, interfaces, and resources. Furthermore, intuitive service assurance capabilities ensure swift and accurate failure identification and fault isolation, creating a network solution with unparalleled reliability.

Networking	FE, 1Ge, 10GE
Networking	V.35, X.21, RS-232, RS-449, V.24, V.11, V.36
Teleprotection	IEEE-C37.94
Voice	E1/T1, FXO/FXS 2/4 E&M, Omni
Video	Ethernet with PoE+



Seamless Support for MPLS-TP and IP/MPLS

Multi-stack MPLS allows critical infrastructures to benefit from both MPLS-TP and IP/MPLS, facilitating their coexistence within the same network. This ensures a seamless and risk-free transition between MPLS-TP and IP/MPLS, eliminating the need for product replacements, hardware upgrades, or additional training. With multi-stack MPLS, IT/OT convergence becomes a reality, and when required, introducing new deterministic packet transport techniques, such as SR-TE and network slicing, becomes straightforward. Additionally, it equips the critical industry with the technology required to offer telecommunications services as a Utelco.

Efficiently Delivering Services

Multi-stack MPLS provides CI network operators with the flexibility to select the most appropriate transport technology on a service-by-service basis. For instance, legacy and mission-critical services are typically mapped to MPLS-TP, while corporate voice and data L3 VPN services are typically mapped to IP/MPLS. This flexibility ensures the network meets the performance requirements of each service, while minimizing network and operational costs.

Summary

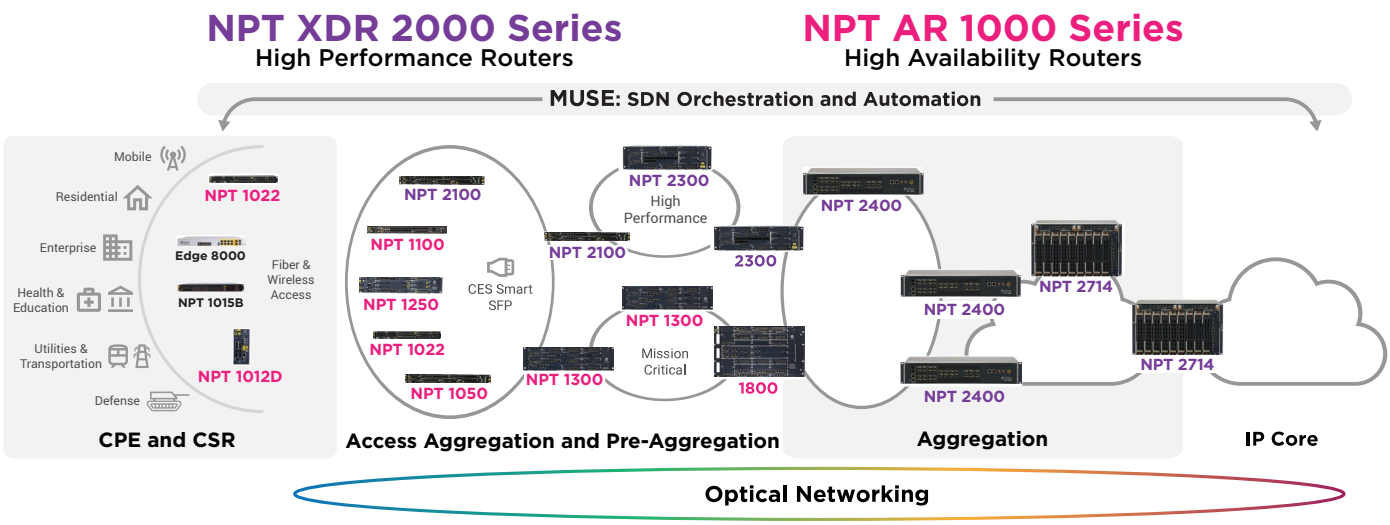
To support the transition to new packet-based services and phase out legacy SDH/SONET transport networks, CI operators need a unified packet transport network. This network must support modern IP/MPLS packet transport technologies while providing the deterministic packet transport for legacy services.

Ribbon's NPT is a comprehensive packet transport family offering a rich suite of products for mission-critical networks. It supports a diverse range of packet transport technologies, including IP/MPLS, SR-TE, RSVP-TE, EVPN, FlexAlgo, Network Slicing, and MPLS-TP, along with the circuit emulation essential for supporting legacy TDM/PCM services.

With over 20 years of experience, Ribbon provides field-proven products and processes which have enabled our customers to evolve their mission-critical networks. NPT's unique multi-stack MPLS, combined with Circuit Emulation (CES) capabilities and robust, customizable migration processes, allows critical industries to confidently retire their legacy SDH/SONET networks. This transition delivers a packet transport network that critical industries can use to continue support legacy services as needed while providing the flexibility to accommodate new packet-based services as they are introduced.

Ribbon's modern packet transport network leverages multi-stack MPLS to facilitate continuous evolution. This enables the critical infrastructure to transition their networks from supporting basic Layer 2 and MEF services provided by MPLS-TP and Carrier Ethernet to offering advanced SR-TE, EVPN, and Layer 3 VPN technologies. These advancements support IT/OT convergence and even provide telecommunications services as a Utelco.

Ribbon's Access and Aggregation Routers



Modern Interface Support

- 10GE/25GE/100GE/400GE
- 10/100/1000 Base-T
- PoE+
- CWDM, DWDM
- 100G/200G/400G Coherent
- Timing: 1PPS, 10MHz, GNSS ANT, ToD and BITS (8273.2 Class C)
- FlexE

Legacy Interface Support

- FXO, FXS
- 2 wire, 4 wire, E&M
- V.24 Transparent, Synchronous Asynchronous (RS232)
- V.35/V.11, V.36/RS422/RS449
- C37.94
- 64K Codirectional
- Dry Contact
- CEP, SAToP, CESoPSN
- E1/T1, E3/DS3
- STM-1/OC-3, STM-4/OC-12, STM-16/OC-48, STM-16/OC-48

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**.

Contact Us Contact us to learn more about Ribbon solutions.