Delivering Ethernet Business Services

Introduction

Ciena is playing a fundamental role in the delivery of Ethernet services as this important market evolves. To do so, Ciena is separating Ethernet as a service from the underlying transport layer capabilities—the service is what the end-customer buys; the transport layer is how those services are delivered.

This paper defines the key connectivity services available in the market today—Ethernet, IP, and virtualized services (such as SD-WAN)—to provide a view on market size and growth and the associated trends. It examines the strategic drivers, the important delivery trends, and the most common protocol technologies for delivering Ethernet services. Finally, it describes the role Ciena plays in the delivery of Ethernet services—what the company is doing today, how that will evolve over the short to medium term, and the benefits it can deliver.

Market and services overview

Connectivity services

The market for telecoms packet networking services covers three main service categories, which are set to undergo a transformation over the next few years.

L2 (Ethernet) services

MEF Carrier Ethernet Services (E-Line, E-LAN, E-Tree, E-Access)

- These services are offered by the majority of Communication Service Providers (CSPs) globally, and are widely used and demanded by enterprise customers. The Metro Ethernet Forum (MEF) has standardized these services among both CSPs and enterprises.
- E-Line and E-LAN are offered by all CSPs, where E-Tree is only offered by a handful globally.
- E-Access is a wholesale carrier access service offered by some, but not all CSPs.

L3 (IP) services

MPLS IP-VPN (also known as MPLS L3 VPN)

- This has been the mainstay of IP WAN network services for the past 20 years and is offered by every CSP on the planet. The services all have subtle differences between operators, typically around number of Class of Services (CoS) profiles offered, which complicates intercarrier connectivity. CSPs look to differentiate with value-added capabilities such as high availability.

IPv6 6PE/6VPE

- This is a mechanism that allows devices with IPv6 addresses to be carried over an IPv4-based MPLS IP-VPN network. This mechanism has been available for a number of years, and has seen renewed interest because of the impending 5G deployments as well as IPv4 address depletion. The 6PE/6VPE functionality runs on the PE router that is connected to the CE router using IPv6. 6PE is for CE routers connected to a standard PE router; 6VPE is the variant where the PE port runs on a VRF.

Virtualized services (such as SD-WAN)

- The latest and hottest part of the market is virtualized services. By far the most popular service is SD-WAN, which is available as both a PNF and VNF.
- Most IT, cloud and communication providers either have an SD-WAN offer or a clear road map to deploying one. SD-WAN can be quite confusing as it is an overlay service that can run over multiple underlay networks (Dedicated Internet Access (DIA), Ethernet, MPLS IP-VPN).

Where would networks use these different service types?

Ethernet services tend to suit less complex data topologies and lower numbers (100s) of customer endpoints. Ethernet can provide higher speed, lower latency, and more deterministic performance than IP-VPN and SD-WAN, so it tends to be used where those are requirements. Ethernet is often used by enterprises who want to retain full control of their IP routing domain, rather than have to interwork with a service provider's IP-VPN routing domain.

Typical Ethernet applications include any point-to-point connection including data center connectivity; very high bandwidth connectivity (>1 Gb/s); backhaul/aggregation of some mobile base station traffic; backhaul/aggregation of business services IP traffic; and best-effort connectivity for some verticals (such as local government).

IP-VPN services (in MPLS guise) have been around for 20 years and provide a very flexible and scalable approach to connect large numbers (1,000s) of IP endpoints together. With current router technology, IP-VPN speeds above 1 Gb/s tend not to be cost-effective. IP-VPN supports low latency, multiple classes of service, and good levels of resilience/availability. IP-VPN provides support for complex service topologies, and can become part of the overall routing topology in the Enterprise network. IP-VPN tends to be more expensive than Ethernet, especially SD-WAN, but has been the mainstay of enterprise networking over the past decade and more.

Typical IP-VPN applications include enterprise networking connecting large numbers of IP endpoints. IP-VPN endpoints can include branch offices, HQ sites, data centers, and cloud service connection (such as AWS Direct Connect).

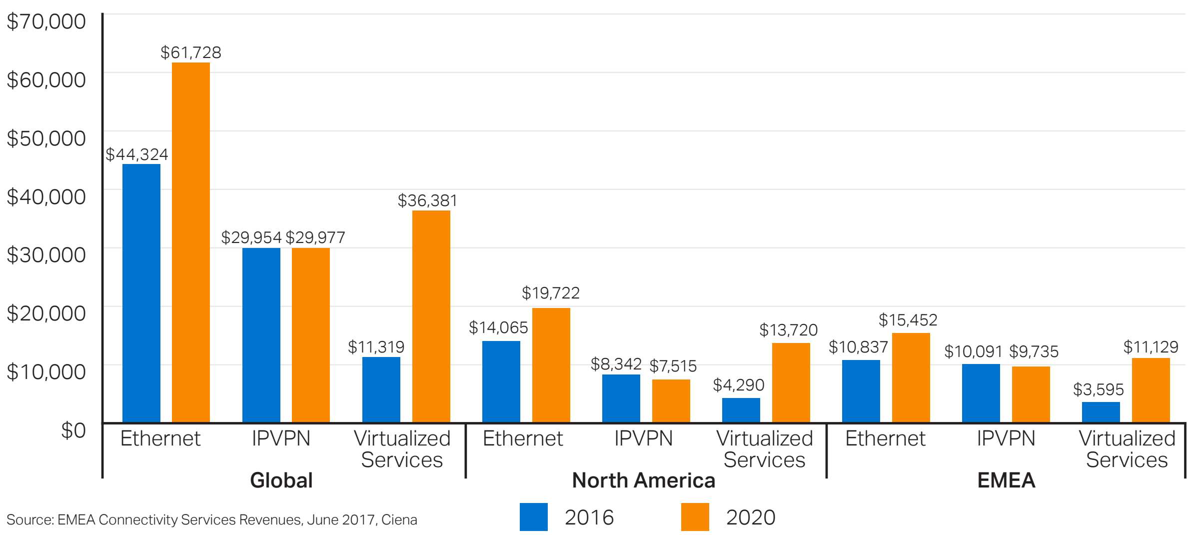
Virtualized services are the trending service capability. SD-WAN is a key variant, effectively being an *overlay* service that rides on top of existing *underlay* services like Dedicated Internet Access (DIA) via Ethernet and IP. SD-WAN is starting to supplant IP-VPN services in many enterprises, mainly due to the fact that SD-WAN delivers similar IP connectivity and performance, but at a lower cost. In reality, enterprises are tending to retain some MPLS connectivity and add in SD-WAN to enhance price performance, with overall increased resilience. There is a trade-off with SD-WAN around the SLAs available when using DIA as an underlay, and the level of security offered.

SD-WAN applications typically are used in three main use cases: large retail operations, small and medium enterprises, and local government/municipalities. With the latter use case, it is effectively augmenting Ethernet services with an application. As it matures, SD-WAN will start to encroach further into where traditional IP-VPNs are being deployed.

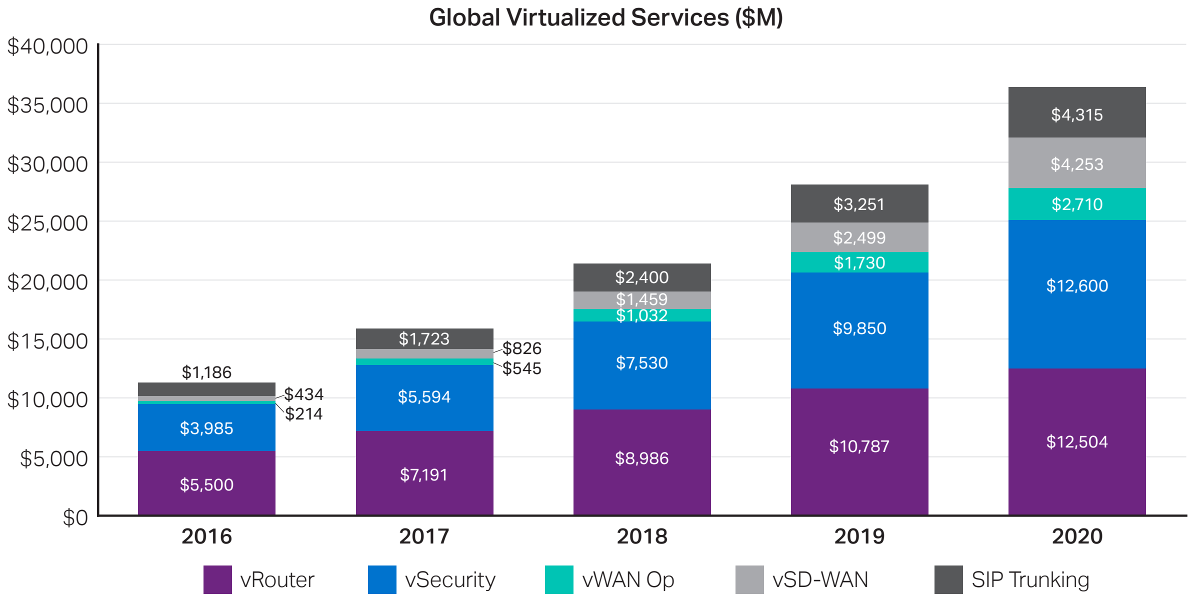
Service trends

In comparison to the relative size and growth of the various services in the market, Ethernet is the largest service category, growing at 10 percent CAGR. MPLS IP-VPN is second largest today, but is flat to declining in terms of growth. Virtualized services are the fastest growing segment, set to overtake IP-VPN by 2022.

Revenue Forecast for Connectivity and Virtualized Services ($M)



Source: EMEA Connectivity Services Revenues, June 2017, Ciena



Source: EMEA Connectivity Services Revenues, June 2017, Ciena

The largest parts of the virtualized services market are vRouter, vSecurity and vSD-WAN.

SD-WAN is set to replace IP-VPN as a L3 connectivity service. CSPs and/or vendors are acquiring the original independent SD-WAN service providers as this market matures.

Within L2 Ethernet services, CSPs are starting to deploy MPLS-based Ethernet services because they scale better than using traditional L2 Carrier Ethernet/G.8032. MPLS supports multiple topology types—hub/spoke and ring rather than G.8032, which only works with rings. MPLS offers more services on a device than G.8032, and more resilience options. MPLS-TE provides an additional benefit over G.8032 around traffic engineering.

Another trend is an evolution toward pervasive networking, which has been triggered by the impending arrival of 5G. Historically, different connectivity service types (residential, business, mobile) have run on completely separate networks at the access/aggregation layer and, in many cases, including the core. With the growth of mobile devices and cloud-based applications, people need access to the same content (business or personal), regardless of their network. So, the paradigm of separate networks is no longer relevant, hence the shift to pervasive networking—simply providing connectivity from whatever device/access network a user is on to the (typically) cloud-based applications they need to access. The arrival of 5G on the horizon, along with mobile connectivity capabilities (mainly speed) equalling fixed connectivity, have accelerated this requirement.

The final trends relate to key geographic differences among the main regions around the world. A few main areas will influence the shape of how networking could evolve in the short to medium term on a regional basis:

- European and APAC populations are much denser and closer than U.S. and Australia
- Europe allows more open access to fiber/ducts/poles than U.S. and APAC
- Data privacy regulations dictate where data (such as IoT) may be stored and shared; in some countries in Europe, it has to stay within borders
- Government regulation around spectrum auctions impact the availability of 5G

Delivering Ethernet services

Key business drivers in delivering Ethernet/IP/virtualized services

IT, cloud and communication providers are focusing on three main drivers around the delivery of Ethernet services:

Simplicity

This is all about driving operational and cost efficiency. Having fewer, less complex network components that are easier to manage is a key driver in this approach, such as reducing the traditional amount of control plane signaling in the network to establish packet-based services and transport. It is not just about the cost of the devices, it is also about reducing the cost of operating the devices, such as enabling network-level programmability and operational data via open standards such as BGP, NETCONF/YANG, and gRPC Telemetry.

Service velocity

This is focused on improving Time to Market (TTM) and Time to Revenue (TTR) using network rollout functions such as Zero-Touch Provisioning (ZTP) and Service Activation Testing (SAT). Being able to configure new services to bring them to market more quickly than the current 12- to 18-month time scales is vital to maintain and improve competitiveness. TTR is a key factor in many new services business cases.

To increase the velocity and efficiency of service assurance, active measurement protocols must be used, including a complete Operations, Administration, and Maintenance (OAM) suite to support the network and service performance monitoring requirements of highly distributed packet network deployments.

Adaptiveness

This relates to the ability to create more service variants, and to be able to instantiate potentially vast numbers of these services in a geographically distributed network.

The main focus is the ability to carry out rapid service creation, deployment, and modification that maintains pace with user demands. This includes new optimized IP services and Software-Defined Networking/Network Functions Virtualization (SDN/NFV) readiness to address key requirements related to 5G and the continued expansion of IP-based business services. A by-product of this approach is the ability to incubate/test new service ideas using a fail-fast approach.

Scaling of the network is a contributing factor of adaptiveness, both for bandwidth (driven by 30 percent/annum traffic growth) and endpoints (5G and IoT).

Approaches to maximizing coverage for new service availability

One of the key factors in market competitiveness is maximizing coverage. There are can use two main approaches for this: self build or wholesale build.

Self build

This provides the greatest level of control for the IT, cloud or communication provider in terms of service differentiation, but is the most resource/capital intensive, and potentially takes the longest time to implement. It has the potential to tie up engineering and operations resources through extensive planning, procurement, and deployment cycles. The trade-off is the opportunity to develop unique market differentiation through both service capability and cost optimization (when compared with a wholesale build approach).

Wholesale build

This can be a good option, depending on a few factors. One is the availability of wholesale capacity in all the areas the network needs to reach. Another is the ability to add value and differentiate over and above the wholesale capability. Regulatory approach is a key driver here in the availability of viable wholesale services, and this can vary by country. There will be a requirement to tie up engineering and operations resources, but not to the same extent as the self build approach. The benefit of this approach is speed of deployment and reduced resource/capital utilization. However, the risk is the possibility of reduced differentiation through service capabilities and a higher cost base.

Trends in delivery capabilities

Three key trends have developed around how IT, cloud and communication providers are looking to deploy networks to support Ethernet services to meet the business drivers of simplicity, service velocity, and adaptiveness.

Disaggregation

Historically, high-capacity, full-function switches and routers have been deployed for Ethernet services. As networking has evolved, it has become clear that every switch or router does not have to run every existing protocol.

What is needed is the ability to run just the protocols required today, and ideally to off load some more centralizable functions from the network devices. This disaggregated approach means more complex networking functions (such as traffic engineering and real-time data analytics) can be centralized onto an orchestration layer.

This has a number of benefits:

- More sophisticated network analytics can be deployed across the whole network, feeding real-time status inputs into the routing functions in each network node.
- Centralizing the complex networking functions allows taking advantage of cloud computing economics.
- As less complex switching/routing and processing capabilities are needed on each network node, merchant silicon can be used to drastically reduce costs.
- Network scaling is much easier to achieve.
- New services can be deployed more quickly and easily, helping to increase service velocity.

Openness

Networks need to be able to work in a multivendor environment across a range of hardware and software solution components. They need to be able to do this in a disaggregated way to avoid the restrictions of the historical vertically integrated approach to solution delivery and quickly assemble new services from a variety of standardized and interoperable service components.

Therefore, openness is a key requirement. This is manifested in a variety of ways:

- Providing an open source approach to software environments (such as GRPC, Linux)
- Being able to integrate and operate VNFs from a variety of suppliers
- Being able to easily interwork with third-party software solutions northbound and southbound through APIs, to build and add functionality
- Having open API SDKs to be able to do this in a DevOps environment

Programmability

Programmability is applicable to a combination of physical and virtual network elements. These programmable elements can be accessed and configured via common, open interfaces that are highly instrumented, with the ability to export real-time network performance telemetry and data. They adjust their resources as needed to meet the demands of the applications running on top of them across an adaptive end-to-end network.

Common protocol technologies used for delivery

There should be a clear distinction between the services being offered and their delivery methods.

For Ethernet services, there are two distinct service sub-types (E-Line/E-Access and E-LAN), each of which can be delivered using a variety of service and transport technologies, as illustrated in the following table.

Service	Service Sub-type	Service technology	Transport technology
Ethernet	E-Line/E-Access	VPWS	MPLS-TP * MPLS *
		Ethernet 802.1ad	G.8032 *
		EVPN	MPLS *
	E-LAN	VPLS	MPLS-TP * MPLS *
		Ethernet 802.1ad	G.8032 *
		EVPN	MPLS *

* Supports the use of QinQ, Ethernet VLAN, or port-level spurs

A range of transport technologies support each service technology.

VPWS is a service technology used for point-to-point Ethernet connections. The service layer is enabled using a static pseudowire or Targeted LDP (T-LDP). It can be run over static MPLS-TP transport or over a 'dynamic' MPLS transport mechanism, of which there are many: LDP, RSVP-TE, BGP, seamless MPLS, and Segment Routing (SR). LDP and RSVP-TE are used predominantly today, but the market is evolving to make use of end-to-end transport technologies like BGP, seamless MPLS, and SR.

VPLS is a service technology used for any-to-any Ethernet connections. It makes use of the same MPLS delivery mechanisms as VPWS in terms of service and transport technologies. VPLS is quite old now, has some limitations mainly related to scale, and likely will be superseded by EVPN in the medium term.

Ethernet 802.1ad is used for both point-to-point and any-to-any Ethernet connectivity. It is a service technology and is partnered with G.8032 as a transport technology.

EVPN is a service technology used for both point-to-point and any-to-any Ethernet connectivity. EVPN uses multiprotocol-BGP for the service layer, and it makes use of the same MPLS transport technologies as VPWS and VPLS. Instead of using flood and learn of MAC addresses (as with VPLS), EVPN uses BGP routing updates to learn about MAC addresses. This avoids network congestion from the flood and learn approach of VPLS, especially in larger networks. EVPN was developed originally for connectivity inside data centers but is now being extended into the WAN environment.

Ciena's role

When it comes to helping deliver Ethernet services, Ciena provides both a comprehensive capability today, and a compelling road map moving forward. Ciena has a rich legacy in providing solutions that deliver MEF Ethernet services, and this is evolving to provide a future-proof capability that meets the key business drivers of simplicity, service velocity, and adaptiveness.

Ciena's solutions today

Ciena provides a range of capabilities today that support most of the possible permutations of Ethernet services, service technologies, and transport technologies.

Service	Service Sub-type	Service technology	Transport technology
Ethernet	E-Line/E-Access	VPWS	MPLS-TP MPLS *
		Ethernet 802.1ad	G.8032
	E-LAN	VPLS	MPLS-TP MPLS *
		Ethernet 802.1ad	G.8032

* Supports LDP, RSVP-TE

The most recent capability to be introduced has been supported by MPLS transport (specifically LDP), which means Ciena can interwork fully in a multivendor MPLS-based network delivering Ethernet services.

Ciena can support both ring and hub-spoke topologies, as well as single vendor and multivendor aggregation architectures, meeting most current network requirements.

Network management is available using OneControl, ESM, and Blue Planet® Manage, Control and Plan (MCP).

The Adaptive Network™

The Adaptive Network is Ciena's vision of a target end-state for networks. Utilizing automation guided by analytics and intent-based policies, the Adaptive Network rapidly scales, self-configures, and self-optimizes by constantly assessing network pressures and demands. The Adaptive Network leverages various elements such as:

- **Network sensors:** A combination of physical and virtual elements that can be accessed and configured via common, open interfaces; they can export data and adjust resources based on inputs received.
- **Operational data:** Network sensors transport real-time network performance telemetry and data up to the network analytics layer.
- **Network analytics:** Big and small network data is analyzed using machine learning, and then turned into actionable insight. To do this, a number of Blue Planet functions (multi-domain and NFV orchestration, MCP, multi-layer analytics; Route Optimization and Assurance) link together to simplify the end-to-end management and automation of network services across hybrid networks. Leveraging these insights can help providers develop smarter, data-driven business policies that enable them to adapt to customer needs in real time and help them understand problems in the network before their customers see them.

Network optimization

The outputs from the analytics function are fed back into the network sensors, adjusting resources as needed to meet the demands of the applications running on the network.

The Adaptive Network vision
Learn more

Adaptive IP™: New IP-based networking

A key part of the Adaptive Network is Adaptive IP—a new capability that will be offered across several of Ciena's access, aggregation, and metro platforms. Over time, Adaptive IP will support a streamlined set of next-generation IP capabilities (including BGP, IS-IS, OSPF, and SR) required of specific target application spaces, such as L3 VPN business services, 5G, and Fiber Deep.

From a customer and end-user perspective, Ciena's modular, open, and highly programmable IP architecture empowers providers with a number of benefits:

- **Improved service velocity:** CSPs and enterprises can improve service velocity with faster deployments, updates, and changes that leverage ZTP, which shortens time to revenue
- **Reduced total cost of network ownership:** Removes operational complexity by eliminating the overhead of power, space, memory, and processing capacity required to implement legacy IP designs
- **Optimized performance:** Allows automation of network configuration, performance management, and optimization with near real-time telemetry information generated to assess network health

A key part of Adaptive IP is Ciena's next-generation SAOS 10.x software—a microservices-based architecture offering an intelligent automation Operating System (OS) incorporating the best programmable cloud-based technology and open interfaces (NETCONF/YANG) into the network, from access to metro. Key notable benefits include the following:

- The ability to beat competitors to market with new and innovative services by enabling a DevOps-based development cycle adapted to specific use cases
- Networks will gain flexibility and more easily control their costs via a software architecture that is decoupled (disaggregated) from hardware

- Service choice will be increased by supporting the use of certified third-party Virtual Network Functions (VNFs) (such as vEncryptor and vFirewall) and openly allowing customers to qualify more VNFs for their own networks at will

Scale without limits
Learn more about Ciena's converged IP and Ethernet solutions

Adaptive IP: Ethernet services delivery features and functionality

Specifically for Ethernet services, Ciena is introducing a range of new Adaptive IP capabilities that will support any and all requirements a network would have in the deployment of Ethernet services, as illustrated in the following table.

Service	Service Sub-type	Service technology	Transport technology
Ethernet	E-Line/E-Access	VPWS	MPLS-TP MPLS *
		Ethernet 802.1ad	G.8032
		EVPN	MPLS *
	E-LAN	VPLS	MPLS-TP MPLS *
		Ethernet 802.1ad	G.8032
		EVPN	MPLS *

* Supports LDP, RSVP-TE, BGP, seamless MPLS, and SR

Service technology updates

New service technology additions focus on EVPN, which makes use of MPLS transport technologies.

Transport technology updates

Ciena is introducing new end-to-end MPLS transport technologies: BGP (various flavors), seamless MPLS, and SR.

SR will take advantage of disaggregation to enable:

- Separation of control plane and data plane signalling in an end-to-end MPLS network
- The abstraction of complex networking functions (such as traffic engineering or real-time data analytics) out of the network nodes and into an orchestration layer

These capabilities will help simplify operations and reduce costs.

Ciena is supporting increased traffic growth through the integration of coherent optics onto the various Ethernet platforms—enabling these platforms to scale through 100 Gb/s to 400 Gb/s and beyond, on a range of sleds and pluggable optics.

Benefits of choosing a Ciena solution

Ciena's Adaptive IP approach helps address three key business drivers: simplicity, service velocity, and adaptiveness.

Simplicity

- Ciena's Adaptive IP enables a reduction in total cost of network ownership by removing operational complexity via the elimination of overhead of power, space, memory, and processing capacity required to implement legacy IP designs.
- Ciena's Blue Planet MCP software offers a unique and comprehensive solution for administration of mission-critical networks that span access, metro, and core domains, and provides unprecedented multi-layer visibility from the photonic to the Ethernet and IP layers. With this innovative management approach, Blue Planet MCP supports a programmable and automated solution that leverages NETCONF/YANG mechanisms to provide fully open approaches to installing, manipulating, and monitoring service behaviors in an SDN environment.
- As IT, communications, and cloud providers and their customers increasingly rely on new Ethernet and IP-based networks, guaranteed service levels must be maintained. These networks must support a broad array of OAM capabilities to ensure they can proactively and reactively maintain and report on the ongoing health of the Ethernet and IP networks and services. Ciena solutions support a comprehensive set of hardware-assisted packet OAM capabilities—including per-service Ethernet fault and performance monitoring, and embedded, line-rate SAT to a full 100 Gb/s—to help guarantee and manage strict, market-differentiating SLAs.

Service velocity

- Improve service velocity with faster deployments, updates, and changes that leverage ZTP.
- Ciena's comprehensive ZTP capability, available across a range of devices, allows the ability to to rapidly deploy new Ethernet and IP-based services in a completely automated manner. With no human intervention required, manual provisioning errors are eliminated. Most importantly, ZTP improves service deployment velocity and significant competitive advantage.
- Service providers can beat competitors to market with new and innovative services by utilizing Blue Planet to implement a DevOps-based development cycle.

Adaptiveness

- Ciena's Adaptive IP solutions allow automation of network configuration, performance management, and optimization with near real-time telemetry information generated to assess network health.
- With Adaptive IP, networks gain flexibility/choice and cost savings by using software that is decoupled ('disaggregated') from hardware. The Adaptive IP stack enables efficient service delivery through wireless or wireline infrastructure with agility and cost efficiency.
- Continued annual growth in metro network bandwidth demand is driving a change in the mix of connections and services, from 1GbE aggregation to 10GbE, and 10GbE aggregation to 100GbE. In addition, demand for high-speed 100GbE UNI services is steadily increasing. This shift toward higher-bandwidth services means metro and regional Ethernet networks, once optimized for lower 1GbE rates, are no longer aligned to changing metro network traffic trends. Ciena provides comprehensive support for all of these key interface speeds across its portfolio of Ethernet and IP solutions.

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