

From Promise to Reality: Extending the Reach of Managed Ethernet Services

Executive Summary

OFFERING A SIMPLE, COST-EFFECTIVE ALTERNATIVE to leased lines and other legacy services, carrier-managed Ethernet is quickly becoming the service of choice for metro- and wide-area connectivity. Industry analysts expect the global market for Ethernet business services to grow to more than \$10 billion by 2010.

Managed Ethernet services support both point-to-point and multipoint-to-multipoint connections. Enterprises use these services to consolidate all their Local Area Network (LAN) and Wide Area Network (WAN) traffic onto a single, familiar architecture. Simpler management and more granular bandwidth allocation make Ethernet services more practical and affordable than legacy services. Further fueling this trend, volume manufacturing is driving Ethernet hardware prices ever downward compared to traditional WAN hardware.

The advantages of managed Ethernet are numerous. With Ethernet, service providers can deliver all types of services—data, voice, video—over the same access facilities. Low-cost Ethernet hardware reduces Capital Expenditure (CAPEX), while operational simplicity shrinks Operating Expenses (OPEX). Managed Ethernet boosts customer retention by providing an easy migration path from legacy services, and creates an IP-friendly foundation for new, value-added carrier services.

To realize Ethernet's full benefits, service providers must deliver managed Ethernet services to all customer sites, including sites not on their own networks. Therefore, the Network Termination Equipment (NTE) and aggregation platforms that support managed Ethernet must operate over a variety of access media and technologies such as fiber, copper, DSL, PDH, and SONET/SDH.

In addition, to achieve expected price points, service providers must meet customers' immediate and future Ethernet bandwidth, management, and Quality of Service (QoS) requirements without disruptive forklift upgrades, and modify these configurations remotely, without costly truck rolls.

Finally, to ensure the highest service availability and quality, Ethernet access platforms must support comprehensive Ethernet Operations, Administration and Maintenance (OAM) capabilities. Standards-based OAM should allow full management and diagnostic capabilities for individual access links and end-to-end services. Service management can be further enhanced through integration of Ethernet OAM with an umbrella management system for complete, unified control of all Ethernet access, switching and transport activity.

Ciena's 3000 Ethernet Access Series meets all requirements for successful Ethernet service delivery and supports carrier-managed Ethernet services over a variety of access media for nearly ubiquitous service reach.

Introduction

Ethernet has dominated LAN technology for years. Recently, service providers have been evaluating and selectively deploying Ethernet as a managed service as well. For enterprises, managed Ethernet offers significant cost savings, granular scalability, and an opportunity to unify LAN and WAN operations. For service providers, it promises reduced CAPEX and OPEX, improved customer retention, and a basis for profitable value-added services. Many expect Ethernet to become the interface of choice for both Metro Area Networks (MANs) and WANs.

To realize its full potential, managed Ethernet services must have a ubiquitous footprint, reaching all customer sites over any available access media and technology. Otherwise, Ethernet's unifying value is lost. Moreover, Ethernet services must be manageable—both at the link level and end-to-end—over all types of access and transport networks. Without complete OAM capability, service providers will not be able to ensure the availability and QoS that enterprises demand.

This white paper examines managed Ethernet services: the types of services and their benefits, the architecture underlying the services, the key challenges to service providers, and the requirements for a

successful solution. Finally, the paper introduces Ciena's 3000 Ethernet Access Series—a flexible portfolio of Ethernet access and aggregation devices—which helps service providers address these requirements.

Ethernet Business Services

Service providers offer enterprises several ways to interconnect their sites. Leased lines, for example, provide transparent point-to-point links that enterprises use to tie together their routers or switches. Frame Relay, ATM and IP services are more economical than leased lines and allow the operator to offer both point-to-point and point-to-multipoint connections. However, these legacy services all have drawbacks, including scaling limitations, long turn-up times, and high operating cost. To use these services, enterprises must install and manage special WAN interface equipment, driving up both CAPEX and OPEX.

Carrier-managed Ethernet Virtual Connections (EVCs) offer a more flexible, economical alternative, and come in two forms: Ethernet Line (E-LINE) services and Ethernet LAN (E-LAN) services, as shown in Figure 1. E-LINE services provide point-to-point connections that can be used as private links between enterprise sites, components of mesh or star networks, or access links to the public Internet or carrier IP services. E-LAN services provide Layer 2 multipoint-to-multipoint connectivity, creating an enterprise-wide LAN that extends over the

MAN or WAN. E-LINES and E-LANs are cost-effective alternatives to legacy leased lines and higher-layer offerings such as IP Virtual Private Networks (VPNs).

Managed Ethernet services offer valuable benefits to enterprises:

- » **Simplicity:** Ethernet is a natural fit for the IP-family protocols that dominate enterprise networking. In addition, managed Ethernet enables enterprises to consolidate all LAN and WAN operations around a single technology. Because Ethernet is a managed service, the enterprise IT staff does not have to learn or manage the transport technologies behind the carrier demarcation point.
- » **Security:** Since managed Ethernet is a Layer 2 service, there is no need for enterprises to disclose IP addressing schemes and topologies or to turn over the management of IP infrastructure to the service provider.
- » **Flexibility:** Ethernet service can be provisioned at almost any bandwidth level from 1 Mb/s up to 1 Gb/s or more. So enterprises can buy bandwidth as needed, scaling up in affordable increments when necessary, generally without changing hardware.
- » **Cost savings:** Managed Ethernet reduces enterprise OPEX because Ethernet interfaces are simpler to install and configure than traditional WAN interfaces, afford a lower cost per bit, and are already familiar to the IT staff. CAPEX is reduced because decades of volume manufacturing have made Ethernet interfaces much less expensive than traditional WAN hardware.

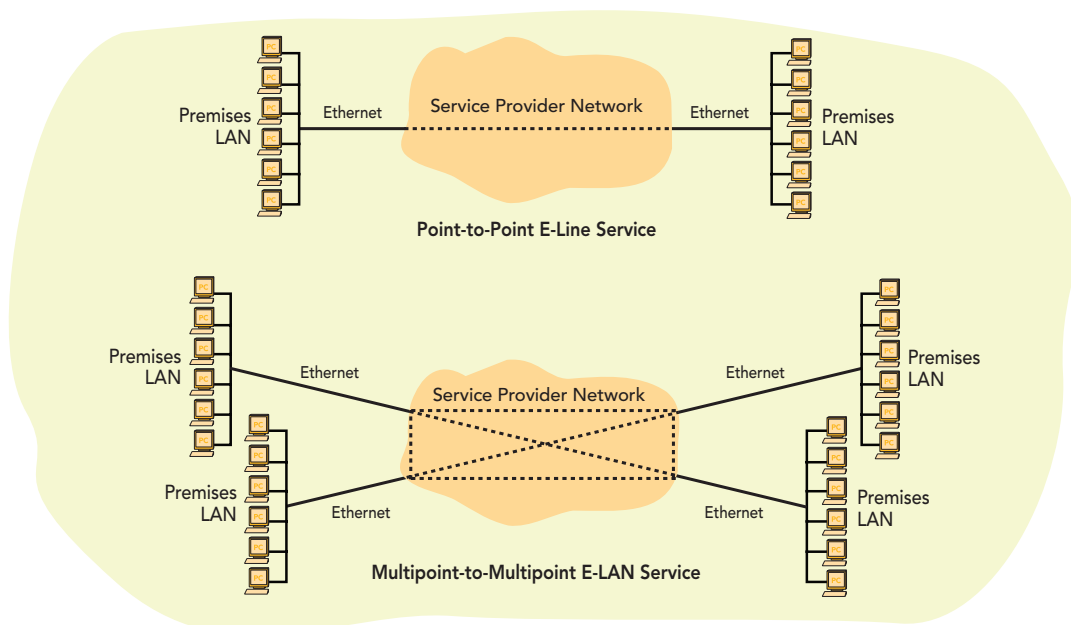


Figure 1. Ethernet Virtual Connection service

Managed Ethernet services also offer valuable benefits to service providers:

- » **Cost savings:** Ethernet reduces carrier OPEX by providing unified support for a broad assortment of IP-based business services, including all types of data, voice and video.
- » **Improved customer retention:** E-LINE and E-LAN services improve customer retention by offering attractive alternatives to legacy services such as leased lines and Frame Relay. Enterprises can easily migrate to flexible, cost-effective Ethernet services without changing providers.
- » **Revenue growth:** Ethernet allows service providers to tailor services to meet individual customer requirements and attract new customers with tiered price points based on different service levels, and forms a foundation for value-added differentiators like VPNs and Class of Service (CoS)-based Service Level Agreements (SLAs). Indeed, Yankee Group forecasts the global wide-area Ethernet service market will increase from \$3.8 billion in 2006 to \$10.8 billion in 2010.
- » **Improved competitiveness:** By leveraging a rich Ethernet-based service portfolio, service providers can compete more successfully, even against newer players.
- » **Rapid payback:** The capital cost of Ethernet Customer Premises Equipment (CPE) is typically comparable to one month of the revenue that it generates, ensuring rapid payback on the service provider's CPE investment.

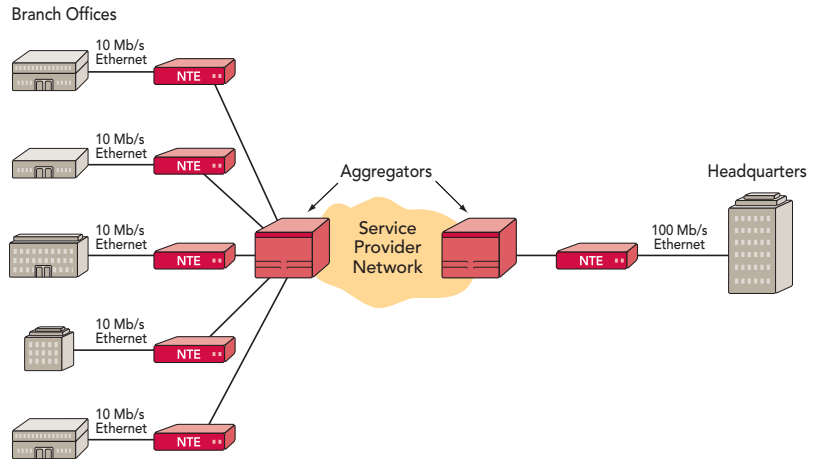


Figure 3. Ethernet services speed matching

Ethernet Services Architecture

The basic architecture of managed Ethernet services is simple, as shown in Figure 2. NTE owned by the service provider and located on the customer premises creates a demarcation point between customer and carrier networks, with a standard Ethernet interface on the customer side and a WAN interface on the carrier side. This extends the reach of the service provider's network all the way to the enterprise while implementation of specific OAM capabilities facilitates monitoring and diagnosis of the access link, as well as the end-to-end service. Generally, links from NTE at multiple sites converge on an aggregator in a service provider's Central Office (CO). The aggregator grooms incoming traffic to fill backbone pipes efficiently, minimizing per-port costs. The service provider's metro- or wide-area Ethernet backbone interconnects the CO-based aggregators to create end-to-end E-LINE and E-LAN services.

Besides basic connectivity, the Ethernet services architecture supports traffic aggregation and speed matching on behalf of the enterprise customer, as shown in Figure 3. Logical connections from multiple remote sites can all be delivered to a single NTE device at the enterprise hub. NTE at the remote sites might, for example, deliver Ethernet services at 10 Mb/s, while the NTE at the hub runs at 100 Mb/s. These aggregation and speed matching capabilities are essential for Internet access,

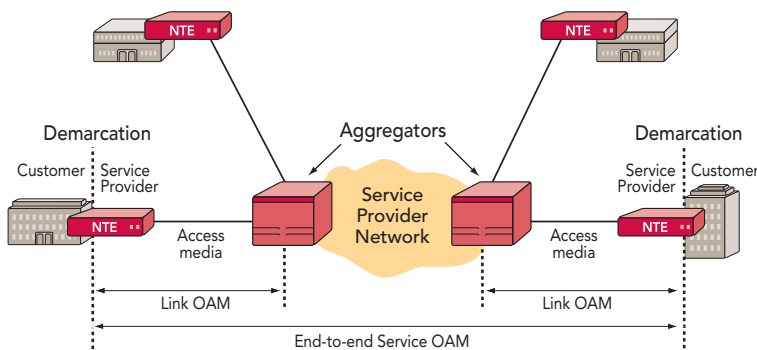


Figure 2. Basic Ethernet services architecture

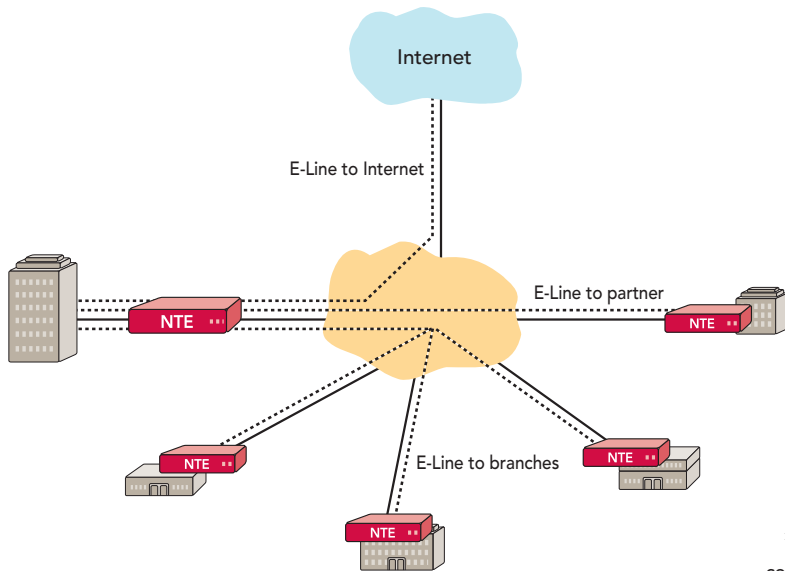


Figure 4. Multi-service Interface Sharing

where logical connections from hundreds or thousands of enterprises terminate at a single Internet Point of Presence (PoP).

The Ethernet services architecture also allows for multiple logical connections and/or managed Ethernet services via a single NTE interface, as shown in Figure 4. An enterprise site might have an Internet access link, an E-LAN connecting to other enterprise sites, and a few E-LINE links to trading partners. All of these logical connections could terminate on a single NTE Ethernet interface on the customer premises, with customer-assigned Virtual LAN (VLAN) tagging to identify the separate flows. Additionally, the Ethernet services architecture allows service providers to use various stacking/encapsulation techniques (such as Q-in-Q and MAC-in-MAC) to separate multiple customers' traffic and VLAN address spaces.

Key Challenges

The benefits of managed Ethernet services are clear and the basic architecture straightforward, but to succeed, the access solution—NTE, aggregators and management tools—must address some key challenges. Unless the access solution meets these challenges, service providers and their enterprise customers cannot realize the full potential of managed Ethernet services.

» **Service reach:** Enterprises should be able to interconnect any or all of their sites, regardless of location. Without ubiquitous reach, enterprises

are stuck with a mix of Ethernet and traditional services, negating the benefits of a unified architecture. A 2006 Heavy Reading survey of Ethernet service providers found that “the ability to provide Ethernet connectivity to any location, regardless of access media, [is] the most important competitive advantage in the market.”¹

» **Service flexibility:** To secure the long-term benefits of managed Ethernet services and to strengthen customer loyalty, service providers must satisfy both immediate and future customer needs, including the ability to adapt without forklift upgrades as industry standards change and evolve.

» **Comprehensive management:** To ensure service quality and compliance with stringent SLAs, service providers need full Ethernet OAM capability, including performance monitoring, fault detection and loopback testing. Network operators must be able to manage and diagnose link-level and end-to-end performance, QoS, availability, and other Ethernet service parameters remotely, no matter which access and wide-area media and technologies are involved.

Solution Requirements

The challenges outlined above translate to specific requirements for Ethernet NTE and aggregators:

SERVICE REACH

To create a ubiquitous footprint, service providers must extend Ethernet services over diverse networks and even deliver services over other providers' access facilities. Therefore, the Ethernet access solution must support both fiber and copper media and a range of access technologies from Time Division Multiplexing (TDM) to packet switching.

Fiber access Optical fiber is the simplest medium for access to managed Ethernet services. The NTE packages customer traffic in standard Ethernet format and sends it over fiber to the CO (and vice versa), providing an intelligent demarcation between end-user and service provider networks, without involving Layer 3 complexities. Fiber access allows service providers to deliver granular and scalable Ethernet services with plenty of headroom for future growth. Ideally, the NTE supports a variety of fiber interface modules and wavelength options for complete flexibility.

TDM access (copper or fiber) To reach customer sites not on a service provider's fiber plant and leverage other providers' access networks, the Ethernet access solution must also support copper media. Most copper access is based on traditional PDH T1/E1 (1.5/2.0 Mb/s) or DS3/E3 (45/34 Mb/s) private lines. The NTE or aggregator maps Ethernet frames into TDM payloads at the ingress. The payloads are carried across the TDM network like any other traffic and mapped back into Ethernet frames at the egress. To fill the gap between T1/E1 and T3/E3, multiple T1/E1 circuits can be "bonded" to form access pipes at intermediate rates such as 3.0 Mb/s or 4.5 Mb/s. Similar techniques apply to fiber-based SONET/SDH access, such as Virtual Concatenation (VCAT) and Link Adjustment Capacity Scheme (LCAS), which support flexible provisioning and dynamic reconfiguration of right-sized bandwidth bundles.

DSL access DSL offers another type of copper access, using advanced modem technology to achieve high-speed transport over ordinary twisted-pair local loops. Like TDM circuit bonding, DSL bonding combines multiple DSL pairs to support a range of access speeds. For example, the G.SHDSL standard supports bonding of up to eight copper pairs for symmetric service at speeds ranging from 2.3 Mb/s to 15 Mb/s, and the emerging VDSL2 standard defines symmetric services at speeds up to 100 Mb/s.

SERVICE FLEXIBILITY

Each customer represents a unique constellation of service, speed and management requirements. One may want sub-10 Mb/s service with no QoS guarantees, while another requires 100 Mb/s service with strict SLAs. Moreover, each customer's requirements will evolve over time. The ability to fit each customer's current requirements, to respond flexibly to changes, and to provide end-to-end management throughout will be key differentiators for Ethernet service providers.

The Ethernet access solution, therefore, should support a range of service configurations, including tiered and differentiated services, and grow and change with the customer without expensive truck rolls or lengthy service disruptions. Network operators should be able to configure NTE remotely, adjusting bandwidth rates, turning

on circuit bonding, activating and deactivating individual ports, and downloading new management features. With a sufficiently flexible Ethernet access solution, the service provider can be cost-competitive from day one and remain competitive as customer requirements grow and evolve.

COMPREHENSIVE MANAGEMENT

OAM is a critical tool and a powerful differentiator for managed Ethernet services. Effective OAM enables rapid fault detection, performance management and distribution of vital information, so network operators can detect and isolate faults before they escalate. By eliminating truck rolls and other manual intervention, strong OAM also increases service availability and reduces OPEX. With the right OAM tools, service providers can offer carrier-class service and sign stringent, high-value SLAs with confidence.

Ethernet OAM standards are still maturing. So far, four key specifications have emerged from standards bodies:

- » IEEE 802.3ah Ethernet in the First Mile (EFM) includes mechanisms for link operation and health monitoring, fault isolation, and remote CPE management
- » IEEE 802.1ag Connectivity Fault Management (CFM) specifies end-to-end fault detection for Ethernet transport services
- » ITU-T Y.1731 augments 802.1ag with performance monitoring capabilities
- » MEF 10 Ethernet Services Attributes provides a standard framework for describing Ethernet services, including performance characteristics pertinent to SLAs

Support for these emerging standards is essential to the successful delivery of managed Ethernet services.

3000 Ethernet Access Series

Ciena's 3000 Series provides Ethernet demarcation and aggregation devices that enable service providers to deliver managed Ethernet services over virtually any access media, for ubiquitous customer reach. Support for Ethernet OAM standards, plus MEF compliance, affords complete remote management and diagnostic capability. Flexible, field-upgradeable platforms provide the ability to adapt as

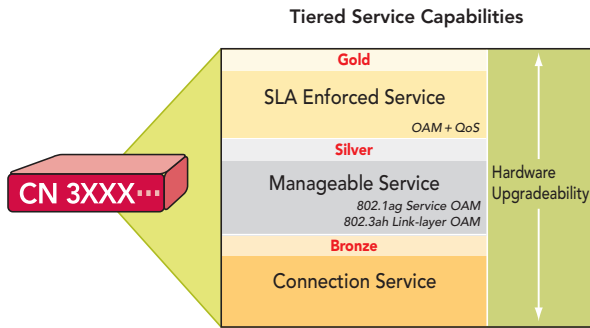


Figure 5. Maximum service flexibility

industry standards evolve, and enable a cost-effective transition from legacy services to a tiered menu of managed Ethernet services. For example, the same 3000 Series NTE could support a Bronze-level basic connection service, a Silver-level service with granular levels of link- and service-layer OAM support, and a Gold-level service with full SLA-enforced traffic classification and prioritization, as shown in Figure 5.

Network Termination Equipment

ETHERNET OVER FIBER

3000 Series Ethernet-over-Fiber NTE models support managed Ethernet services delivered over fiber connections in Gigabit Ethernet format, extending the service provider's reach while enabling management of differentiated services. Available configurations provide a range of subscriber-side 10/100/1000 Mb/s Ethernet ports and carrier-side Gigabit Ethernet ports.

ETHERNET OVER TDM

Ethernet-over-TDM devices provide access to managed Ethernet services over copper-based T1/E1 and DS3/E3 WAN links, allowing service providers to extend their Ethernet services footprint to almost any customer over existing off-net or third-party access networks. Available configurations provide a range of subscriber-side 10/100/1000 Mb/s Ethernet ports and carrier-side T1/E1 or T3/E3 ports. Multiple carrier-side ports can be bonded to create logical access links at increasing bandwidth levels.

For fiber-based SONET/SDH access, the 3000 Series includes network termination equipment that supports subscriber-side Ethernet ports and carrier-side OC-3/STM-1 SONET/SDH ports.

ETHERNET OVER DSL

Planned Ethernet-over-DSL NTE will support DSL-based Ethernet access, providing subscriber-side 10/100/1000-Mb/s Ethernet ports and carrier-side G.SHDSL or VDSL2 ports. Support for DSL bonding will create a range of access capacities.

MULTISERVICE

Multiservice NTE models support both TDM and Ethernet services over copper or fiber access infrastructures. Interfaces include Ethernet, T1/E1 and DS3/E3 on a single platform. Support for the IETF's Pseudowire Emulation Edge-to-Edge (PWE3) architecture provides TDM-over-IP (TDMoIP) transport with the same performance characteristics as a native TDM circuit. In addition to Ethernet and TDM business services, multiservice devices are particularly well suited for wireless backhaul applications.

Central Office Aggregators

The 3000 Series includes a variety of Ethernet service aggregators with modular and standalone configurations. The modular NTE aggregator allows service providers to mix Ethernet, SONET/SDH, T1/E1 and DS3/E3 ports on a single device. This highly reliable, scalable, pay-as-you-grow chassis aggregates traffic from multiple NTE devices, thereby minimizing end-to-end port costs. The modular aggregator also can be deployed at customer premises as a larger capacity multiservice NTE.

Compact standalone aggregators provide industry-leading high-density Ethernet service aggregation for Ethernet-over-Fiber and sub-100 Mb/s Ethernet-over-TDM services.

Network Management

Ciena's ON-Center® Network and Service Management Suite is an integrated network management solution that provides standard northbound interfaces and delivers end-to-end provisioning,

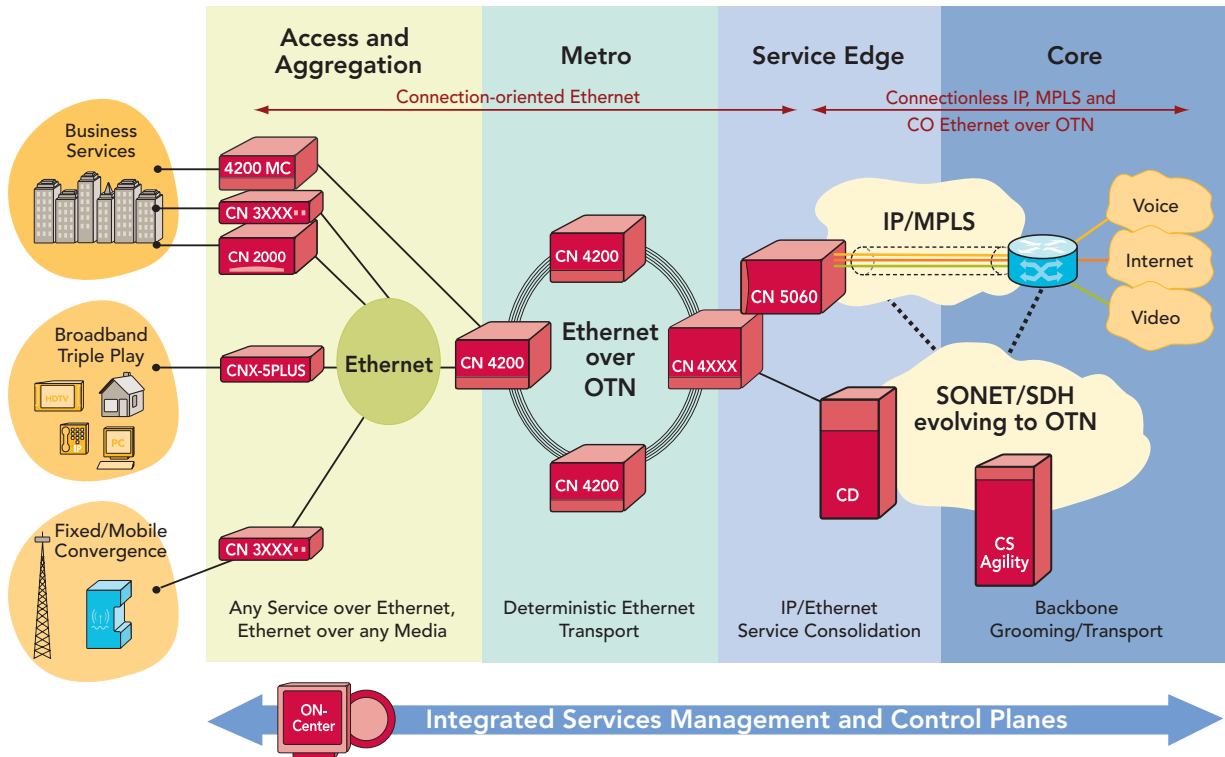


Figure 6. Ciena's FlexSelect Architecture for Ethernet transport services

configuration, performance and health monitoring across Ciena's network platforms. While not a requirement, 3000 Series products can be fully managed by ON-Center, together with the rest of Ciena's FlexSelect™ Architecture for Ethernet transport and service, as shown in Figure 6, simplifying the rollout of enhanced Ethernet services and supporting seamless integration of third-party operations support systems.

ON-Center Ethernet Access Manager is a plug-and-play module that fits under the ON-Center management umbrella, offering full Fault Configuration Accounting Performance Security (FCAPS) control of the 3000 Series for the complete lifecycle of service deployment, activation, fault isolation and monitoring. Additionally, the ON-Center Service Layer Manager provides end-to-end service level monitoring and SLA verification.

Conclusion

Managed Ethernet services promise valuable benefits for enterprises and service providers alike. Enterprises can unify LAN/WAN infrastructure, reduce OPEX, and eliminate costly WAN interfaces. Service providers can consolidate diverse service offerings, improve customer retention, and offer revenue-enhancing value-added services. To realize all this potential, however, the Ethernet access solution must provide nearly ubiquitous service reach over a variety of access media and technologies and be flexible enough to satisfy customers' current and future requirements without disruptive swap-outs. The Ethernet access solution must also support and adapt to emerging, standards-based Ethernet OAM for carrier-class manageability. Ciena's 3000 Ethernet Access Series meets and exceeds all of these requirements making it the most comprehensive, flexible and manageable Ethernet access solution in the industry.