IP NGN Carrier Ethernet Design: Powering the Connected Life in the Zettabyte Era

Executive Summary

Service providers worldwide agree that the Carrier Ethernet and IP/Multiprotocol Label Switching (MPLS) technology will pave the way to next-generation networks; however, there are multiple approaches to designing Carrier Ethernet networks. This paper provides an overview of recommendations from Cisco for designing an IP Next-Generation Network (NGN) Carrier Ethernet infrastructure.

Service providers are facing increasing challenges brought on by service convergence and stiff market competition. To maintain growth and profitability, service providers need to:

- Accommodate surging demand for broadband services
- Maintain competitive residential and business service offerings
- Avoid service commoditization by offering new and premium services
- Strengthen profitability by increasing revenue while reducing total cost of ownership
- Migrate existing ATM/Frame Relay to more cost-effective Carrier Ethernet service
- Protect and grow business services in parallel with consumer services

The Cisco® IP NGN Carrier Ethernet Design supports these business goals with five essential attributes: **convergence, resiliency, intelligence, scalability, and manageability.**

The Cisco IP NGN Carrier Ethernet Design facilitates a converged network infrastructure that cost-effectively delivers new and future services. This network infrastructure supports the bandwidth and network requirements for Broadcast TV Video (BTV) and video-on-demand (VoD) services, among others. All network services are fully supported, including:

- Consumer and residential services
- Business services
- Broadband mobility services
- Wholesale services

Using the Cisco IP NGN Carrier Ethernet Design, service provider organizations can transport profitable services in a consistent and reliable manner, providing a high quality of experience (QoE) to an entirely new generation of subscribers.

Overview of the Cisco IP NGN Carrier Ethernet Design

The Cisco IP NGN Carrier Ethernet design enables service provider network to meet the specific demands of each service, with consistent reliability and availability. This network design provides the foundation for end-to-end service transport, from the access layer to the IP/MPLS core. Integration between service and application-layer components delivers a converged and intelligent network model that scales to meet future requirements.

One of the key principles of the Cisco IP NGN Carrier Ethernet design is that multiple networking technologies are used to provide optimal flexibility for current and next-generation service offerings. These technologies include Ethernet over MPLS (EoMPLS), Layer 3 Protocol Independent Multicast-Source Specific Multicast (PIM-SSM), MPLS VPN, IP over dense wavelength-division multiplexing (IPoDWDM), Hierarchal Virtual Private LAN Service (H-VPLS), and IEEE 802.1ad as well as emerging Ethernet, IP, and MPLS technologies. This allows service providers to support a broad range of applications while minimizing the capital and operating expenses associated with the network infrastructure. (To read a business case and ROI analysis of Carrier Ethernet design, please visit www.cisco.com/en/US/netsol/ns561/networking_solutions_white_papers_list.html.)

This flexible approach to network design may be contrasted with a more rigid approach (advocated by some network designers) proposing that H-VPLS be the sole technology used to aggregate all services. While H-VPLS is a good technology for some multi-point business Ethernet services, it is not optimal for all applications and services. H-VPLS is not well suited to distributing broadcast video because it requires the use of proprietary multicast technology that is not inherently scalable. Cisco recommends native Layer 3 IP multicast: a proven, scalable, IETF standards based approach to delivering IP multicast traffic. Similarly, in many cases, Layer 3 MPLS VPNs provide the best approach to creating a wholesale service due to the ubiquity of MPLS VPNs in service provider networks. For this reason, Cisco advocates a flexible approach to the IP NGN Carrier Ethernet design that minimizes the total cost of ownership of the access and aggregation network while supporting consistent, reliable service transport for a broad range of applications and services.

The IP NGN Carrier Ethernet Design employs a highly scalable method to delivering residential IPTV by using standards-based IP multicast to deliver broadcast video over the IP network. Protocol Independent Multicast (PIM) is the only IP multicast protocol that has been proven to operate reliably on a large scale. In addition, the IP NGN Carrier Ethernet Design supports the consistent fast routing convergence and rapid channel-change capabilities expected by business and consumer video service subscribers.

The IP NGN Carrier Ethernet Design is used in combination with the Cisco Service Exchange Framework (SEF) to provide a robust and flexible approach to offering a wide variety of residential, business, mobile, and wholesale services.

Network Services Evolution

A service provider's agility and flexibility in service delivery are critical to its long-term success. Most large service providers need the flexibility to offer residential, business, mobile, and wholesale services. This section of the paper gives an overview of current service requirements and provides a roadmap to the future.

Residential Services

A popular strategy to maximize service revenues and minimize subscriber turnover is to offer a complete set of bundled triple-play services to residential subscribers that include:

- Voice
- High-speed Internet
- Broadcast TV and Video On Demand (VoD)

Bundled services are offered at attractive price points to encourage subscribers to purchase all services from a single provider. Multimedia service integration is an important factor for IP convergence in the network. Voice services are delivered using VoIP and video services are delivered using IPTV and IP VoD. In order to accommodate triple-play, it is vital that the network be able to scale to tens and even hundreds of Gbps.[1]

Large traffic growth is expected to result from a steady increase in demand for VoD and high-definition (HD) content delivered over both IPTV multicast and VoD unicast connections. To support this ongoing trend, the IP NGN Carrier Ethernet Design effectively scales video transport from 1 Gbps to 10 Gbps at line rate, evolving to 100 Gbps and beyond, while greatly increasing the total number of supported multicast groups and broadcast TV channels.

Business Services

Business subscribers are an important segment of many service providers' customer base. The main business services that must be provided by the network today are:

- MPLS VPN
- Carrier Ethernet connectivity
- Managed services

Carrier Ethernet connectivity services have been defined by the Metro Ethernet Forum (MEF) to include E-Line, E-LAN, and E-Tree service types, which are defined as follows:

- **E-Line** is based on a point-to-point Ethernet Virtual Connection. Two E-Line services are defined:
    - Ethernet Private Line (EPL): A very simple and basic point-to-point service characterized by low frame delay, frame delay variation, and frame loss ratio. No service multiplexing is allowed, and other than a committed information rate (CIR) no class of service (CoS) (Bandwidth Profiling) is allowed.
    - Ethernet Virtual Private Line (EVPL): A point-to-point service wherein service multiplexing (more than one Ethernet Virtual Connection) is allowed. The individual Ethernet Virtual Circuits can be defined with a rich set of Bandwidth Profiles and Layer 2 Control Protocol Processing methods as defined by the Metro Ethernet Forum.
- **E-LAN** is based on a multipoint-to-multipoint Ethernet Virtual Connection. Service multiplexing (more than one Ethernet Virtual Circuit at the same UNI) is permitted, as is the rich set of performance assurances defined by the MEF such as CIR with an associated Committed Burst Size (CBS) and Excess Information Rate (EIR).
- **E-Tree** is a point-to-multipoint ELAN service in which the spoke "leaves" can communicate with the hub or "root" location but not with each other. Typical application for E-Tree is in franchise operations.

Business services typically provide secure bandwidth with dedicated Quality of Service (QoS). This can be done either at Layer 3 using an MPLS VPN[2] or directly over Ethernet using a Layer 2 Carrier Ethernet service.[3] Additionally, many businesses favor outsourcing management of WAN routers and firewalls to the service provider (see www.cisco.com/en/US/netsol/ns546/networking_solutions_solution_category.html). The Carrier Ethernet network must be able to offer all these services with secure and dedicated bandwidth.

[1] http://www.cisco.com/en/US/netsol/ns561/networking_solutions_white_papers_list.html.
[2] MPLS VPN service is a standard specified by RFC 2547bis. It allows service providers to offer a virtual IP network to customers that rides on top of their MPLS network infrastructure. Customers can connect to the MPLS VPN using a variety of access technologies, including DSL, Frame Relay, T1, and Ethernet.
[3] Carrier Ethernet services are specified by the Metro Ethernet Forum: http://www.metroEthernetforum.org/

Optimized Broadband Mobility

Mobile wireless networks are poised to become a primary vehicle for a wide variety of communications applications. Service providers are focusing on building networks that are capable of delivering a host of real-time multimedia applications in addition to supporting business-class data applications and services.

Mobile Backhaul

Mobile service providers need to build a robust yet flexible IP transport network that takes advantage of packet economics. At the same time they must also support 2G, 3G, and emerging 4G technologies while continuing to align their network architecture with Third-Generation Partnership Project (3GPP/3GGPP2) recommendations. To achieve these goals, mobile service providers must evolve their Radio Access Network (RAN) transport from traditional circuit-based technology to a packet-based solution.

The Cisco Mobile Transport over Pseudowires (MToP) solution uses industry-standard (PWE3) pseudowires to extend the features and benefits of the packet-based core into the RAN. The IP NGN Carrier Ethernet Design integrates the MToP solution using circuit-emulation-over-packet (CEoP) shared port adapters (SPAs) that work with traditional 2G and 3G radio equipment for IP RAN backhaul.

MPLS-based Pseudowires are well-suited to meet next-generation RAN requirements. They provide lower-cost transport, can flexibly support both Layer 2 and Layer 3 packet switching and routing requirements, and simultaneously support the diverse QoS requirements of data packets and circuit switched voice. The Cisco Mobile Transport over Pseudowires (MToP) solution effectively flattens the multiple layers of the RAN onto a single MPLS network by encapsulating and transporting TDM, Frame Relay, and ATM traffic over MPLS.

With MToP, Cisco extends IP/MPLS from the core to the RAN. The MToP solution is a highly scalable, high-performance platform that provides a common architecture and operations, administration, maintenance, and provisioning (OAM&P) from the core to aggregation nodes. It is designed for ultimate flexibility, simultaneously supporting 2G, 3G, and 4G cell-site aggregation for Code Division Multiple Access (CDMA), Global System for Mobile Communications (GSM), and WiMAX networks.

The MToP network capabilities are combined with the integrated Cisco Content Services Gateway (CSG) modules to create a differentiated billing model through traffic analysis, data mining, content filtering, and intelligent enforcement.

The IP NGN Carrier Ethernet Design supports broadband services integration with PDSN/GGSN networks, enabling providers to further reduce costs by using IP networks to backhaul wireline and mobile traffic, avoiding the need to build additional capacity into costly TDM networks. Mobile backhaul services to the cell site are complemented by the Cisco Mobile Wireless Router (MWR) platform, supporting trouble-free expansion to support emerging 4G technologies.

IP RAN Optimization

The Cisco IP RAN Optimization solution optimizes GSM and UMTS traffic at the cell site using IP and helps to enable end-to-end IP services. In typical deployments, mobile wireless access routers optimize and aggregate GSM and UMTS traffic at the cell site. In doing so, they reduce operator dependency on leased T1/E1 lines. The routers support traditional narrowband (T1/E1) and high-speed IP broadband (xDSL, WiMAX, Native Ethernet) RAN backhaul networks for greater scalability and network flexibility. Having the network intelligence of an IP routing device at the cell site gives operators the ability to deploy new services such as IP cameras for surveillance, IP telephony, Wi-Fi/WiMAX access, Internet connectivity, and location-based services to reach new customers.

The Cisco ONS 15454 Multiservice Provisioning Platform (MSPP) also provides scalable transport aggregation and optimization services for backhaul traffic at the base station controller/radio network controller (BSC/RNC) site. This platform connects multiple cell-site mobile wireless routers to a BSC/RNC, and in doing so can enable the network operator to aggregate hundreds of mobile traffic connections on a single carrier-class platform. The Cisco ONS 15454 MSPP also supports a wide range of TDM and IP features, eliminating the need for dedicated TDM cross-connect and ATM platforms at the BSC/RNC site.

Mobile IP: WiMAX

WiMAX is a fourth-generation (4G) wireless solution based on the IEEE 802.16e standard for delivering advanced broadband wireless services in emerging, high-growth, and developed markets. Mobile IP technologies can be used to provide ubiquitous service and enable service providers to deliver a persistent connection for users, independent of their location. The IP NGN Carrier Ethernet Design supports an integrated Broadband Wireless Gateway (BWG) to perform Access Service Network (ASN) gateway IP functions for end-to-end QoS, Admission Control, mobility, and security.

Metropolitan Wi-Fi Mesh Networking

The Cisco IP NGN Carrier Ethernet Design is unique in its ability to converge services over Ethernet, including metropolitan Wi-Fi mesh networking. The Wireless Services Module (WiSM), integrated in the Cisco 7600 Series Routers, offers secure Wi-Fi access-point aggregation capabilities, enabling providers to scale and manage metropolitan Wi-Fi mesh networks. The WiSM supports Lightweight Access Point Protocol (LWAPP) while providing extensive integrated security capabilities such as Wi-Fi Protected Access 2 (WPA2) and various types of the Extensible Authentication Protocol (EAP), including Protected EAP (PEAP).

The Cisco IP NGN Carrier Ethernet Design supports a wide range of evolving broadband mobility services and can be adapted to support future high-bandwidth mobile applications (such as Long-Term Evolution [LTE]). This design supports easy and secure roaming, while providing integrated QoS capabilities to optimize the mobile user experience.

Wholesale Services

Many service providers offer both residential and business wholesale services to other retail service providers. Retail service providers typically require interconnectivity to their subscribers over a tunnel or VPN. A wholesale service provider might provide DSL access network infrastructure for a retail service provider’s Internet customers. The wholesale provider might connect each subscriber to the retail provider using a Layer 2 Tunneling Protocol (L2TP) backhaul tunnel across the Internet. The IP NGN Carrier Ethernet Design supports wholesale transport services using either MPLS tunnels or Layer 2 VPNs. If a service provider wishes to offer a complete access and aggregation network as a wholesale service to retail internet or applications service provider, the IP NGN Carrier Ethernet Design supports consistent service delivery using Ethernet, IP/MPLS, and VPN technologies to provide the necessary levels of security and QoS to the retail service providers and their end customers. In effect, the retail service providers do not own any network transport equipment or facilities and they look to a wholesale provider for these capabilities. The end customer relationship is with the retail service provider, and the service transport is provided by the wholesale service provider.

Service Evolution

The future will bring continued convergence across residential, business, and mobile services. Today most customers have separate mobile and landline phone service; however, in the future many service providers will offer a converged fixed-mobile service. Customers will subscribe to a single phone service that will be delivered either to their cell phone, landline, or soft IP phone (on their PC) depending on their location and their preferences. Similarly, service providers will offer converged video services that will be delivered to an HDTV, PC, cell phone, or wireless PDA based on customer preference. The overall industry trend will be any service, any screen, with fully personalized services and integrated multimedia applications for both business and entertainment.

Figure 1. Global IP Traffic Growth Forecast

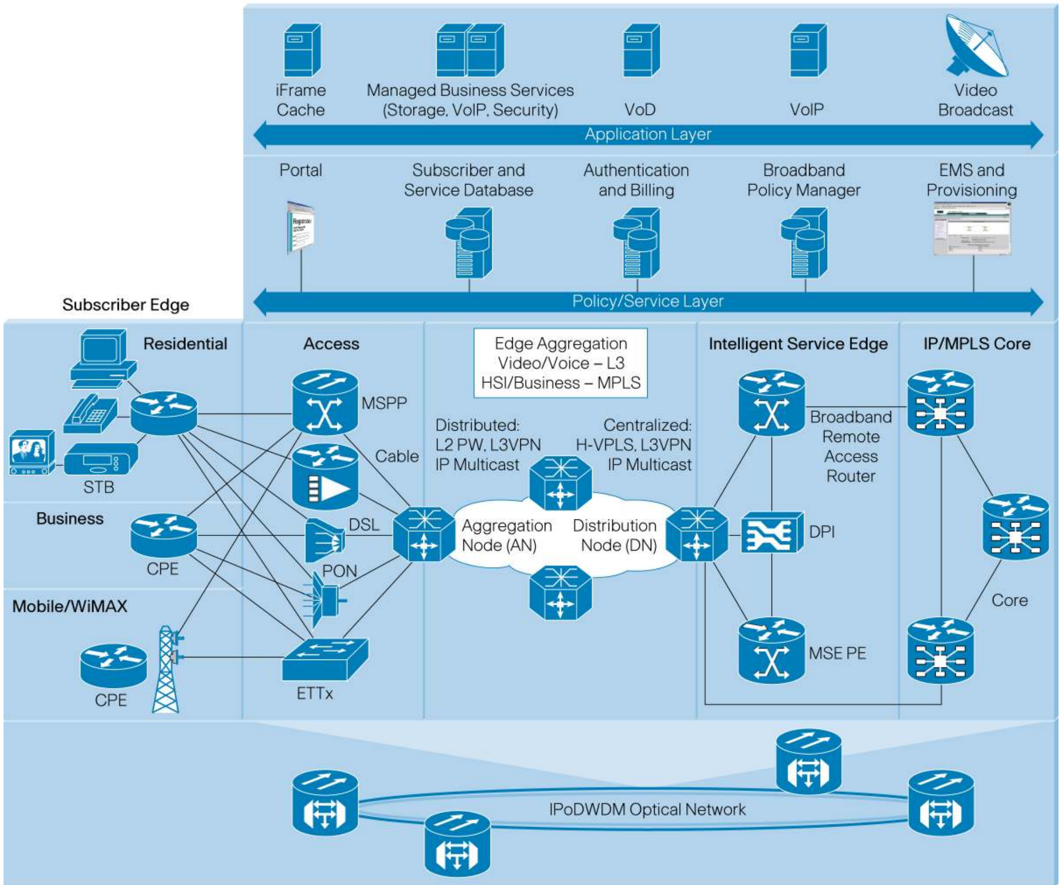
IP NGN Carrier Ethernet Design

The IP NGN Carrier Ethernet Design incorporates Service Exchange Framework (SEF) components such as the Cisco Intelligent Services Gateway (ISG). The Carrier Ethernet network includes a hierarchy of elements that are depicted Figure 2. These elements are:

- **Access**: Provides access to residential and business customers over DSL, fiber, cable, or wireless.
- **Carrier Ethernet aggregation**: Aggregates the access network across a Carrier Ethernet network and provides interconnectivity to the IP/MPLS edge and IP/MPLS core.
- **IPoDWDM optical network**: Enables optical aggregation services with intelligent Ethernet multiplexing using MPLS/IP over dense wavelength division multiplexing (IPoDWDM).
- **Intelligent service edge**: Interfaces services with the IP/MPLS core; this is the provider edge for both residential and business subscriber services.
- **IP/MPLS core**: Provides scalable IP/MPLS routing in the core network.

- **Policy/service layer**: Provides broadband policy management to control service delivery – a key component of the Service Exchange Framework.

Figure 2. IP NGN Carrier Ethernet Design



Access

The access component of the network provides physical wired or wireless access to subscribers. The Carrier Ethernet network must provide transport for all types of access networks and devices, including SONET and SDH MSPP networks, cable, DSL, PON, E-FTTx, WiMAX, 3G Wireless, and Wi-Fi hotspot and hotzone networks. Furthermore, services must be crafted based on the type of customer and the type of access network.

Carrier Ethernet Aggregation

The Carrier Ethernet aggregation network is the foundation of the IP NGN Carrier Ethernet Design. It provides Ethernet transport for all types of services, customers, and access technologies, and scales to support the transport of 1-Gbps to 10-Gbps line-rate services and will evolve to 100-Gbps capacity and beyond . The Carrier Ethernet Design allows all services to be optimized independently, by supporting multiple Layer 2/Layer 3 technologies in the Ethernet transport network. These technologies and/or protocols include:

- Layer 3 routing with PIM-SSM
- Layer 3 MPLS VPN and multicast VPN (RFC 2547bis)
- H-VPLS

- EoMPLS (Pseudowires)
- IEEE 802.1q, 802.1ad, 802.1ah
- IPoDWDM

One reason that it is critical to support multiple protocols in the aggregation network is that different customers, services, and applications have different requirements that can not be addressed by a single, universal approach to network design. Another reason that multiple protocols and technologies must be supported is that service providers have unique approaches to network architecture and design. The flexibility of the IP NGN Carrier Ethernet design allows service providers to design the network according to their own design guidelines and architecture, not those of any particular vendor.

Any of the protocols specified earlier can be used for any service with the exception of residential video broadcast service. Because of the critical quality of experience (QoE) requirements for video broadcast services, the optimal delivery technology is Layer 3 IP multicast with PIM-SSM over MPLS with Fast Reroute (FRR). This provides a highly scalable and reliable architecture for broadcast TV service. Similarly, wholesale residential broadcast video service should use Layer 3 multicast over an MPLS VPN (RFC 2547bis) to provide both scalability and logical separation from other retail networks and customers.

While service providers are free to choose transport protocols that best suit their network architecture and applications, Cisco does offer recommended protocols to optimize service delivery (Table 1). In general, EoMPLS Pseudowire transport is recommended for many services that require Ethernet transport with differentiated QoS. Because EoMPLS uses IETF Pseudowire standards, it is not only scalable, but also delivers enhanced QoS characteristics.

Table 1. Recommended Protocols for Different Services

Service	Recommended Transport Protocols	Transport Function
Residential High-Speed Internet	EoMPLS or IEEE 802.1ad	Backhaul Internet traffic from the access network to the Broadband Remote Access Router for AAA and service control. Provide QoS, tiered, quota-based, and usage-based Internet access.
Residential VoIP	EoMPLS *or* Layer 3 IP Routing over MPLS FRR	Connect signaling traffic to softswitch and RTP traffic to Internet or core IP network. Provide QoS.
Residential IPTV	Layer 3 PIM SSM over MPLS FRR	Broadcast TV service with massive scalability, fast recovery from failures, and excellent QoE.
Residential Video on Demand	Layer 3 IP Routing over MPLS FRR	Video-on-demand service with massive scalability, fast recovery from failures, and excellent QoE.
Business Ethernet Private Line (EPL)	EoMPLS or IEEE 802.1ad	Transport of Ethernet circuit at full data rate with no statistical multiplexing. This requires QoS.
Business Ethernet Virtual Private Line (EVPL)	EoMPLS or IEEE 802.1ad	Transport of Ethernet Virtual Connection with CIR/EIR and statistical multiplexing gain.
Business MPLS VPN	MPLS or IEEE 802.1ad	Transport of subscriber Ethernet Virtual Connection to MSE router that is the provider edge of the MPLS VPN service. CIR/EIR guarantees bandwidth.
Business E-LAN	H-VPLS *or* IEEE 802.1ad	Multipoint virtual LAN service for business customers. CIR/EIR guarantees bandwidth.
Mobile Backhaul	EoMPLS or IEEE 802.1ad	Pseudowire backhaul for 3G, WiMAX, and Wi-Fi networks.
Wholesale Residential High-Speed Internet	EoMPLS or IEEE 802.1ad	Pseudowire backhaul from the access network to the retail service provider.
Wholesale IPTV and VoD	RFC 2547bis MPLS VPN with multicast	Private IP network with multicast that interconnects the retail service provider with the access network.
Wholesale Business Services	EoMPLS or IEEE 802.1ad	Provide transport from the business customer to the retail service provider with EIR/CIR bandwidth guaranties.

IPoDWDM Optical Network

To accommodate the massive growth in video traffic and IPTV applications, service providers are upgrading their core and aggregation networks using IP over dense wavelength-division multiplexing (IPoDWDM) technology. The Cisco IPoDWDM portfolio includes a suite of powerful features that enhance scalability and efficiency, helping fulfill the promise of extremely flexible, end-to-end optical provisioning. The underlying optical DWDM network consists of Cisco ONS 15454 Multiservice Transport Platforms (MSTPs) that integrate easily with the aggregation, edge, and core nodes, and ultimately results in significant capital savings.

This optical transport aggregation smoothly integrates into the IP NGN Carrier Ethernet Design through IPoDWDM interconnections. Integrating IP and DWDM in the core and aggregation networks eliminates the need for transponders and allows signals to stay in the optical domain without electrical conversion. Using the wavelength drop-and-insertion capabilities on the MSTP, IPoDWDM supports the creation of logical topologies that are independent of the physical topology. The integration of ITU G.709 functionality allows the support of Forward Error Correction (FEC)/Extended FEC (E-FEC) and OAM capabilities, which help extend the reach as well as provide for performance management.

Intelligent Service Edge

The intelligent service edge is where many network services are terminated and managed. There are three main functions performed here:

- Broadband remote access service aggregation
- Multiservice provider edge routing
- Deep Packet Inspection (DPI)

Broadband Network Gateway

The broadband network gateway is primarily responsible for residential high-speed Internet subscriber management and wholesale services. It implements an Intelligent Services Gateway (ISG) function for residential Internet access and VoIP telephony services. Subscriber traffic is transported across the Ethernet access and aggregation network and terminated on the broadband remote access router. Functions provided by the broadband network gateway include:

- Termination of residential high-speed Internet services
- Termination, routing, or tunneling of wholesale high-speed Internet using L2TP or MPLS VPN
- RADIUS, AAA, and dynamic subscriber and policy control for PPPoE and IPoE sessions

Multiservice Edge

Business traffic is transported across the Carrier Ethernet network to the multiservice edge where MPLS VPN services, existing Frame Relay services and ATM services are terminated. The multiservice provider edge performs virtual IP routing (RFC 2547bis) functionality as well as Frame Relay and ATM-to-MPLS interworking functionality.

Deep Packet Inspection

The Deep Packet Inspection (DPI) function implements application-layer traffic management and premium Internet service-delivery control. It carries out traffic policing and monitoring (for example, rate limiting of P2P traffic) and also is an integral part of the Service Exchange Framework.

IP/MPLS Core

The IP/MPLS core is the backbone network that interconnects all Ethernet aggregation networks. The core network is based on the highly scalable Cisco CRS-1 router. All packet forwarding in the core network should be carried out by scalable Layer 3 IP/MPLS routers.

Carrier-Grade Ethernet Management

Service providers today require service-fulfillment capabilities with rapid automation and activation that maps from order entry to the operational business processes that drive device configuration. As converged networks become more prevalent, service fulfillment requirements become more complex resulting in networks that could have thousands of routers, each supporting a variety of customers with unique configurations and identities that are constantly changing.

Carrier Ethernet networks must be able to support a converged and multiservice infrastructure with a management framework that can support consumer, business, wholesale, VoIP, video, and broadband mobility services. The IP NGN Carrier Ethernet Design includes a comprehensive, open infrastructure of service activation and assurance methods to support the workflow and business processes in a multi-vendor network environment. The key components are as follows:

- **Network Management System (NMS):** Provides the element management functions for the access, aggregation, and edge network layers, and creates a platform for value-added applications (plug-ins) such as assurance and performance management. Ideally, the NMS should “abstract” the managed device interfaces (APIs) from the “core” network management software so that device management interfaces can be easily supported and scaled. This removes any dependencies on direct network communications with the management software, and gives the service provider the flexibility to support a wide variety and number of network devices.
- **Activation management:** This allows Carrier Ethernet business and residential services to be created end-to-end through the network with support for services that follow the user and high availability, as well as flexible support for third-party equipment.
- **Assurance management:** This provides the ability to easily detect and repair network faults with 100 percent accuracy. It employs and builds on E-OAM capabilities for discovery and performance monitoring and supports multiple technologies from traditional Ethernet to MPLS-based approaches including EoMPLS, H-VPLS, Layer 3 VPNs, and mobile backhaul.

Ethernet Operations, Administration, and Maintenance[4]

Ethernet OAM includes those capabilities that allow a service provider to create, monitor, and troubleshoot Ethernet links and services in a standardized fashion. It helps service providers offer end-to-end service assurance across the IP/MPLS core, the Ethernet Metro, and to the customer premises. The following protocols are the building blocks for Ethernet OAM:

- IEEE 802.1ag: Connectivity Fault Management (CFM)
- ITU-T Y.1731: OAM functions and mechanisms for Ethernet-based networks
- IEEE 802.3ah: Ethernet Link OAM (EFM OAM)
- MEF E-LMI: Ethernet Local Management Interface

[4] For more details on Ethernet OAM, please visit: http://www.cisco.com/en/US/prod/collateral/routers/ps368/prod_white_paper0900aecd804a0266_ns577_Networking_Solutions_White_Paper.html.

- Cisco IP SLA, which relies on CFM and is used for in-band performance management

The IP NGN Carrier Ethernet Design provides comprehensive and automated instrumentation with Ethernet OAM capabilities that allow service providers to manage service connectivity all the way to the customer premises.

Network Availability Service-Level Agreements

Service providers typically require assurance that their network meets or exceeds specified availability targets. By working with Cisco Advanced Services, service providers can build and operate their networks with carrier-class availability, backed by Cisco SLAs. Cisco's suite of lifecycle services and operational best practices help providers manage and maintain a network with a high degree of availability.

Video Services

One of the most challenging and important services carried over the IP NGN Carrier Ethernet network is video. Video services consist of broadcast IPTV and VoD. Both these services can carry either standard-definition (SD) or high-definition (HD) content. Video is important because it can contribute large revenues to a service provider. It is challenging because of the quantity of stream-oriented traffic generated. Unlike Internet traffic, video traffic is intolerant of delays, packet loss, and network outages. Packet loss ratios that are greater then 10^{-6} and outages greater than 2–3 seconds can seriously compromise video quality.

As part of its IP NGN Carrier Ethernet Design, Cisco has a comprehensive solution for delivering high-quality and high-availability IPTV and VoD. This solution is described more fully in another white paper entitled "Delivering Video Quality in Your IPTV Deployment."[5] The core benefits of Cisco's IP NGN video-delivery solution include:

- Layer 3 video distribution with enhanced PIM-SSM and IGMP providing consistent sub-second convergence and recovery from all types of failure scenarios. PIM is a highly scalable and robust protocol that is proven in large multicast networks.
- Both IPTV and VoD are controlled by a robust Cisco Integrated Video Admission Control (VCAC) solution that monitors network-topology changes and traffic and provides throttling of video admission if necessary. This prevents network meltdowns that could be caused by allowing video traffic to exceeding network capacity.
- The Cisco solution supports rapid channel change that reduces channel-change times from several seconds to less than 1 second by initiating video streams in less than 100 milliseconds (ms) after a request is made.
- The Cisco Video Assurance Management Solution (VAMS) provides real-time, centralized monitoring for broadcast video transport. It monitors video streams in real time and sends proactive alerts to providers if picture quality is degraded, enabling them to determine the cause of the degradation and correct it before call centers are overwhelmed. In addition, the VAMS maintains and tracks the dynamic mapping of video channels to multicast addresses, giving service providers a means to easily pinpoint issues with video quality anywhere in their network.

[5] www.cisco.com/application/pdf/en/us/guest/netsol/ns610/c654/cdccont_0900aecd8057f290.pdf

Service Exchange Framework

As network services make the transition from triple play to any-service-any-screen over converged wireline and mobile networks, service policy management and control become essential components of the network infrastructure. Furthermore, services must be device- and access-independent. To achieve true access independence, network operators must achieve better understanding, visibility, and control of their networks by answering such questions as who their subscribers are and what services are they authorized to use.

Service providers must be able to dynamically control network access, determine the identity of subscribers, and gain a better understanding of services they use “on-the-fly.” With greater granular visibility and control, service providers can achieve new levels of insight into customer activity while simultaneously delivering differentiated and value-added new services, more securely and more profitably.

Some of the key benefits of the Cisco Service Exchange Framework (SEF) are:

- Managing point-to-point (P2P) applications
- Empowering subscribers by allowing them to personalize services
- Helping ensure high-quality video delivery by implementing video admission control
- Enabling new business models for service providers to create premium services

The SEF is composed of two primary layers: the policy-management layer and the packet-forwarding and processing layer. The policy-management layer configures services based on subscriber profiles and service definitions and controls the components in the packet-forwarding layer to implement these services. The policy-management layer is implemented using a policy server, and the packet-forwarding layer is implemented using:

- Integrated Services Gateway (ISG): A software component residing on routers and switches that enables advanced services
- Service Control Engine (SCE): A DPI engine providing traffic shaping, monitoring, and service control

The Service Exchange Framework (SEF) is a key element of the IP NGN Architecture with integrated intelligence embedded in the purpose-built platforms of the IP NGN Carrier Ethernet Design, enabling next-generation personalized subscriber and application services. For more information on SEF, please visit www.cisco.com/en/US/products/ps7045/index.html.

Conclusion

The IP NGN Carrier Ethernet Design provides the flexibility to support current and next-generation services and the scalability to support increasing network traffic. Service provider business can build an infrastructure with carrier-class reliability and provide consistent high quality of experience (QoE) to end users with a single converged Carrier Ethernet network designed to cost-effectively support residential, business, mobile backhaul, and wholesale services. Many technologies are supported to optimize service transport, allowing service provider engineers and architects to select the optimum network design for the specific services, applications, and customers they are serving.

Appendix

Cisco Products

Table 2 matches Cisco products with the elements of the IP NGN Carrier Ethernet Design.

Table 2. Cisco Products That Support Each Element of the NGN Carrier Ethernet Design

Elements of Carrier Ethernet Design	Cisco Products
Access	• Linksys® WAG-310G • Cisco ME 3400 and 3400E Series Ethernet Access Switches • Cisco Catalyst 3750 Metro Series Switches • Cisco Catalyst 4500 and 4500E Series Switches • Cisco ME 4500 Series Switches • Cisco Catalyst 6500 Series Switches • Cisco ME 6524 Ethernet Switch
Edge aggregation	• Cisco 7600 Series Routers
Intelligent service edge	• Cisco ASR 1000 Series Aggregation Services Routers (broadband network gateway) • Cisco 10000 Series Routers (broadband network gateway) • Cisco 7200 Series Routers (broadband network gateway) • Cisco 7300 Series Routers (broadband network gateway) • Cisco 12000 Series Routers (multiservice provider edge) • Cisco SCE 1010 Service Control Engine (DPI) • Cisco SCE 2020 Service Control Engine (DPI)
IP/MPLS Core	• Cisco CRS-1 Carrier Routing System
IPoDWDM	• Cisco CRS-1 Carrier Routing System • Cisco 7600 Series Routers • Cisco 12000 Series Routers • Cisco ONS 15454 Multiservice Transport Platform (MSTP)
Mobility	• Cisco MWR-1941-DC Mobile Wireless Edge Router • Cisco MWR-2941-DC Mobile Wireless Router • Cisco 7600 Series Routers with Wireless Services Module (WiSM)
Service Exchange Framework	• Cisco Intelligent Services Gateway (ISG) • Cisco SCE 1010 and 2020 Service Control Engines

Glossary

Table 3. Acronyms and Definitions

Acronym	Definition
AAA	In computer security, AAA stands for “authentication, authorization, and accounting”. Authentication refers to the confirmation that a user who is requesting services is a valid user of the network services requested. Authorization refers to the granting of specific types of service (including "no service") to a user, based on their authentication, what services they are requesting, and the current system state. Accounting refers to the tracking of the consumption of network resources by users. This information may be used for management, planning, billing, or other purposes.
CIR	Committed Information Rate or CIR in a Carrier Ethernet network is the average bandwidth for an Ethernet Virtual Circuit guaranteed by a service provider.
EIR	Excess Information Rate or EIR is the maximum rate that a Carrier Ethernet subscriber can burst to assuming that on average they do not exceed the CIR.
EoMPLS	Transport of native Ethernet over an MPLS Pseudowire.

Acronym	Definition
H-VPLS	Virtual private LAN service (VPLS) is a way to provide Ethernet-based multipoint-to-multipoint communication over IP/MPLS networks. It allows geographically dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudowires. The technologies that can be used as pseud-wire can be Ethernet over MPLS, L2TPv3 or even GRE. There are two IETF standards describing VPLS establishment, currently in Internet Draft status, but expected to be published as RFCs soon. VPLS requires a full mesh of LSPs which has the n^2 scaling problem. H-VPLS helps solve this problem by dividing the virtual LAN into separate hierarchies.
IEEE 802.1ad	IEEE 802.1ad (Provider Bridges) is an amendment to IEEE standard IEEE 802.1Q-1998, intended to develop an architecture and bridge protocols to provide separate instances of the MAC services to multiple independent users of a Bridged Local Area Network in a manner that does not require cooperation among the users, and requires a minimum of cooperation between the users and the provider of the MAC service. This is a standard version of the Q-in-Q protocol used by Cisco for Carrier Ethernet Service.
IEEE 802.1ah	Provider Backbone Bridges (PBB) is being formalized by IEEE 802.1ah standards. It allows for layering the Ethernet network into customer and provider domains with complete isolation among their MAC addresses. It defines a B-DA and B-SA to indicate the backbone source and destination address. It also defines B-VID (backbone VLAN ID) and I-SID (Service Instance VLAN ID).
IEEE 802.1q	IEEE 802.1Q was a project in the IEEE 802 standards process to develop a mechanism to allow multiple bridged networks to transparently share the same physical network link without leakage of information between networks (i.e., trunking). IEEE 802.1Q is also the name of the standard issued by this process, and in common usage the name of the encapsulation protocol used to implement this mechanism over Ethernet networks. IEEE 802.1Q also defines the meaning of a virtual LAN or VLAN with respect to the specific conceptual model underpinning bridging at the MAC layer and to the IEEE 802.1D spanning tree protocol. This protocol allows for individual VLANs to communicate with one another with the use of a Layer 3 (network) router.
IPoE	IP over Ethernet is used in DSL and PON access networks in place of PPPoE.
Layer 2	Layer 2 of the protocol stack. This typically refers to the set of Ethernet protocols that operate below the IP layer of the protocol stack.
L2TP	Layer 2 Tunneling Protocol (L2TP) is a tunneling protocol used to support virtual private networks (VPNs).
Layer 3	Layer 3 of the OSI protocol stack. This refers to the Internet protocol used for routing in the Internet.
LTE (aka 4G)	Long Term Evolution is a project name an “all IP” standard for mobile traffic that will increase the broadband capabilities beyond current 3G mobile technologies.
MPLS VPN	A Layer 3 virtual IP network specified by RFC 2547bis. It used a combination of BGP routing and MPLS forwarding to create a virtual IP network on top of a service provider’s physical IP network. MPLS VPN services are replacing Frame Relay and ATM services.
PIM SSM	A family of multicast routing protocols that can provide one-to-many and many-to-many distribution of data over the Internet. The "protocol-independent" part refers to the fact that PIM does not include its own topology discovery mechanism, but instead uses routing information supplied by other traditional routing protocols such as Border Gateway Protocol (BGP). PIM Source Specific Multicast (PIM-SSM) builds trees that are rooted in just one source, offering a more secure and scalable model for a limited amount of applications (mostly broadcasting of content). In SSM, an IP datagram is transmitted by a source S to an SSM destination address G, and receivers can receive this datagram by subscribing to channel (S,G). See informational RFC 3569.
PPPoE	PPPoE, Point-to-Point Protocol over Ethernet, is a network protocol for encapsulating PPP frames in Ethernet frames. It is used mainly with ADSL services. It offers standard PPP features such as authentication, encryption, and compression.
Pseudowire	Emulation of a native service over a Packet Switched Network (PSN). The native service may be ATM, Frame Relay, Ethernet, low-rate TDM, or SONET/SDH, while the PSN may be MPLS, IP (either IPv4 or IPv6), or L2TPv3. The first PW specifications were the Martini draft for ATM PWs, and the TDMoIP draft for transport of E1/T1 over IP. In 2001, the IETF set up the PWE3 working group, which was chartered to develop an architecture for service provider edge-to-edge PWs, and service-specific documents detailing the encapsulation techniques. Other standardization forums, including the ITU and the MFA Forum, are also active in producing standards and implementation agreements for PWs.
Q-in-Q	An enhancement of IEEE 802.1q that allows service providers to create Carrier Ethernet VLANs that will preserve the IEEE 802.1q headers used in the internal enterprise VLAN.
QoE	Quality of experience. This is a subjective term that represents the quality of experience in video or voice delivery. For example, if the TV picture is distorted or if the frame freezes this represents a poor level of QoE.
QoS	Quality of service (QoS) refers to control mechanisms that can provide different priority to different users or data flows, or guarantee a certain level of performance to a data flow in accordance with requests from the application program.

Acronym	Definition
RTP	The Real-time Transport Protocol (or RTP) defines a standardized packet format for delivering audio and video over the Internet. It was developed by the Audio-Video Transport Working Group of the IETF and first published in 1996 as RFC 1889, which was made obsolete in 2003 by RFC 3550.
Wi-Fi	Wi-Fi is a brand originally licensed by the Wi-Fi Alliance to describe the underlying technology of wireless local area networks (WLANs) based on the IEEE 802.11 specifications. It was developed to be used for mobile computing devices, such as laptops, in LANs, but is now increasingly used for more services, including Internet and VoIP phone access, gaming, and basic connectivity of consumer electronics such as televisions and DVD players, or digital cameras.
WiMAX	WiMAX is defined as Worldwide Interoperability for Microwave Access by the WiMAX Forum, formed in June 2001 to promote conformance and interoperability of the IEEE 802.16 standard, officially known as WirelessMAN. The Forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL."
3G	3G (or 3-G) is short for third-generation technology. It is used in the context of mobile phone standards. The services associated with 3G provide the ability to transfer simultaneously both voice data (a telephone call) and non-voice data (such as downloading information, exchanging email, and instant messaging). 3G basestations require Ethernet backhaul.

Americas Headquarters
Cisco Systems, Inc.
San Jose, CA

Asia Pacific Headquarters
Cisco Systems (USA) Pte. Ltd.
Singapore

Europe Headquarters
Cisco Systems International BV
Amsterdam, The Netherlands

Cisco has more than 200 offices worldwide. Addresses, phone numbers, and fax numbers are listed on the Cisco Website at **www.cisco.com/go/offices.**

Printed in USA C11-409463-01 09/08