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Metro Optical Ethernet

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1. Introduction

1.1 General

This document describes Qwest® Metro Optical Ethernet® (MOE) service offered by Qwest to its customers. The information provided in this document includes service features, technical specifications, performance objectives, and defines the valid User-Network Interfaces (UNIs).

1.2 Reason for Reissue

- Add SC connector option (at customer premises)
- Add TLS Plus customer access port
- Remove Service Provider port customer restriction
- Change edge switch UPS to optional

1.3 Purpose

The purpose of this document is to describe Qwest Metro Optical Ethernet service. Sufficient technical detail is furnished to enable a customer to select options, bandwidth and interfaces suitable for their application needs. This document describes the technical features of the offering. It is not the intent of this document to provide ordering information beyond specific, available Network Channel and Network Channel Interface Codes.

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2. Service Description

2.1 General

This chapter provides a comprehensive description of Qwest® Metro Optical Ethernet® (MOE) service, and is intended to help customers understand the various types and characteristics of Qwest MOE, and to clearly communicate the service capabilities.

2.2 Qwest MOE Service Points

Qwest MOE Service Points are geographic locations, designated by Qwest, where the MOE network is accessible via standard metallic and/or fiber optic Ethernet interfaces. Service Points are those Serving Wire Centers (SWCs), which are entry points into the Qwest MOE network. Qwest Interoffice Facilities (IOF) will be utilized where required to provide access to the nearest MOE core switch and transport customer traffic between Wire Centers within the same Local Access and Transport Area (LATA).

Network Access Links (NALs) are available at Qwest MOE Service Points or to customer building locations served by Qwest Network Disclosed Central Offices (COs) in selected metropolitan areas. Qwest MOE service to buildings without sufficient facilities will be considered on an Individual Case Basis (ICB).

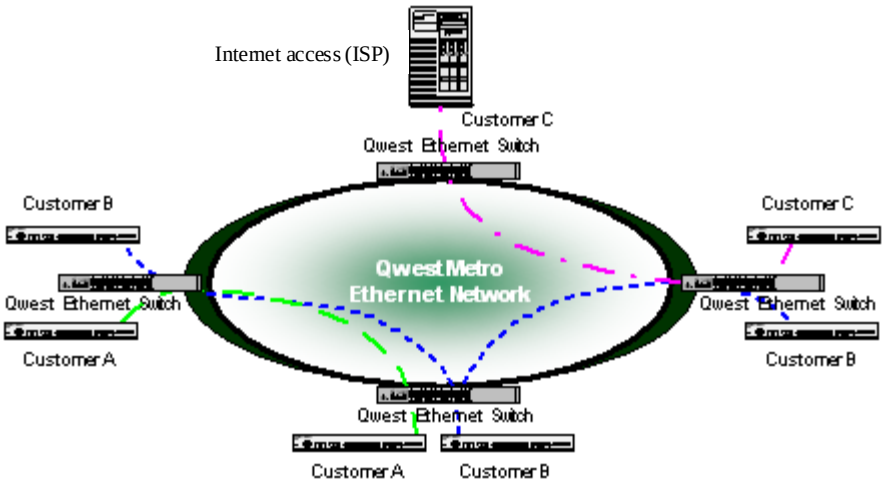
2.3 Overview

Qwest Metro Optical Ethernet (MOE) is a Layer 2 data transport service that offers enterprise and Carrier customers the ability to interconnect standard 10/100/1000 Mbps Local Area Network (LAN) interfaces within a metropolitan area. The Qwest MOE network consists of intelligent Ethernet core and edge switches as well as emerging Ethernet transport technologies such as Next Generation multiservice SONET, WDM or DWDM and G.SHDSL over copper, where available to connect two or more customer-designated locations using Institute of Electrical and Electronics Engineers (IEEE®) 802®.1d Media Access Control (MAC) bridging.

At Qwest's discretion and based upon the customer's bandwidth requirements, various types of equipment may be placed at End-User premises to deliver electrical and optical Ethernet User-Network Interfaces (UNIs). Customer traffic will be transported from each UNI to a Qwest Central Office (CO) core switch using a rate-limited Network Access Link (NAL). NALs are available in customer-specified bandwidth increments from 5 Mbps up to 1 Gbps. The physical UNI as well as NAL bandwidth can be different at each location.

Qwest MOE UNIs may be at End-User premises, Interexchange Carrier (IC) or Internet Service Provider (ISP) Points-of-Presence (POPs). Each individual MOE customer's User-Network Interfaces or Network Access Links will be connected to a multipoint Virtual LAN (VLAN). For customers A, B and C in Figure 2-1, a single VLAN allows each of their locations to communicate with all of their other locations on the Qwest MOE network.

Figure 2-1 Qwest Metro Optical Ethernet Example



The MOE network bandwidth between customer locations is not dedicated to one user, but shared between multiple customers within a metro. VLANs are used to separate individual customer's traffic, ensure security of communications and traffic confidentiality between different customers, and will conform to the IEEE 802.1Q, *Virtual Bridged Local Area Networks* standard. The sharing of the Qwest MOE network is based on committed customer bandwidth profiles and is subject to Qwest oversubscription policy.

Connectivity between customer-designated locations is accomplished by provisioning a customer's VLAN through the Qwest Metro Optical Ethernet edge and core switches, SONET where applicable and fiber optic or copper transport facilities. Qwest will manage the capacity of the MOE network, provide traffic segregation and security, and enforce the bandwidth or throughput for each customer Network Access Link (NAL), i.e. Committed Information Rates (CIRs).

The MOE Layer 2 core switches deployed in the Qwest COs provide IEEE 802.1Q VLAN aggregation as well as connectivity to co-providers' networks in each metro. This includes access to IC Internet Protocol (IP) Wide Area Network (WAN) backbones, ISPs and other service provider's Layer 2/3 metro infrastructures. The core switches send each customer's VLAN traffic to the other core and edge switches as required for a point-to-point or multipoint Ethernet Layer 2 Virtual Private Network (VPN) or high speed Dedicated Internet Access (DIA) service across the shared Qwest MOE network infrastructure. For DIA, Qwest MOE service will connect a customer-designated location to an ISP's local Point-of-Presence (POP). The Qwest MOE network is a flat Layer 2 infrastructure with IP addressing and routing performed only on IC or ISP Layer 3 devices.

2.4 Access Ports and Bandwidth Profiles

The customer will select both a physical access port speed (and type for Gigabit Ethernet) or User-Network Interface (UNI) along with a bandwidth profile or Network Access Link (NAL) for each location. Qwest MOE service offers the following IEEE 802.3-2002, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications* standard UNIs. This standard includes specifications for Ethernet (802.3), Fast Ethernet (802.3u) and Gigabit Ethernet (802.3z).

10Base-T ports

- 10 Mbps full duplex Local Area Network interface over two pairs of twisted-pair telephone or Category 3, 4 or 5 (recommended) copper wire with an RJ-45 connector

100Base-TX ports

- 100 Mbps full duplex Local Area Network interface over two pairs of Category 5 Unshielded Twisted-Pair (UTP) or Shielded Twisted-Pair (STP) copper wire with an RJ-45 connector

1000Base-T ports

- 1000 Mbps full duplex Local Area Network interface using four pairs of Category 5 balanced copper cabling with an RJ-45 connector

1000Base LX ports

- 1000 Mbps full duplex Local Area Network interface using Long Wavelength (1300-1310 nm) lasers over one pair of Single-Mode Fiber (SMF) with a duplex FC-PC or SC connector

1000Base SX ports

- 1000 Mbps full duplex Local Area Network interface using Short Wavelength (850 nm) lasers over one pair of Multi-Mode Fiber (MMF) with a duplex FC-PC or SC connector

The customer will then select a bandwidth profile from 5 Mbps to 1000 Mbps for each access port. The Qwest MOE customer facing switch port will be rate-limited down to this speed. The rate-limited bandwidth or throughput that is specified by the customer for each Network Access Link is available in the following increments:

10 Mbps Ethernet port, rate-limited in 5 Mbps increments

- 5 and 10 Mbps

100 Mbps Ethernet port, rate-limited in 10 Mbps increments

- 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 Mbps

1000 Mbps or Gigabit Ethernet port, rate-limited in 100 Mbps increments

- 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 Mbps

Complete requirements for connecting to the Qwest Metro Optical Ethernet network at the UNI are specified in Chapter 3, Network Interfaces.

2.5 Rate-Limiting and Committed Information Rate

The Qwest MOE network provides hardware-based rate-limiting and traffic shaping to provide control of the traffic flows from multiple customers, which may share the same physical Gigabit Ethernet links. Each customer's individual Qwest MOE Network Access Links (NALs) will be rate-limited at the switch port to a customer-specified bandwidth. The Layer 2 edge and core switches will perform rate-limiting for all Ethernet traffic across all switch ports in the Qwest MOE network in both ingress (entry) and egress (exit) directions.

End-User customers will be port rate-limited while for ICs, ISPs and other Service Providers with any single switch port provisioned to support multiple of their subscribers, who are Qwest MOE End-User customers, rate-limiting will be performed on the individual customer VLANs. Per VLAN ingress and egress policing enables the rate-limiting of individual VLANs on 802.1Q Gigabit Ethernet trunk ports. The Qwest MOE intelligent Ethernet edge and core switches are capable of performing rate-limiting via Committed Information Rate (CIR) functionality. The Qwest MOE CIR is:

- Equal to the (fractional Ethernet) bandwidth profile ordered by the customer per NAL
- Available from 5 Mbps up to 1000 Mbps (the maximum physical port speed)

Ingress and egress CIRs will be equal at all switch ports, i.e. symmetrical. Also, the sum of all CIRs may be greater than the physical Gigabit Ethernet link speed due to oversubscription of the network.

2.6 Full Duplex Operation

Full duplex operation allows simultaneous communication between a pair of Data Terminal Equipment (DTE) or end stations using point-to-point media (dedicated channel). Full duplex operation does not require that transmitters defer, nor do they monitor or react to receive activity, as there is no contention for a shared medium in this mode. Full duplex mode can only be used when all of the following are true:

- The physical medium is capable of supporting simultaneous transmission and reception without interference.
- There are exactly two stations connected with a full duplex point-to-point link. Since there is no contention for use of a shared medium, the multiple access, i.e. Carrier Sense Multiple Access with Collision Detection (CSMA/CD) algorithms are unnecessary.
- Both stations on the LAN are capable of, and have been configured to use, full duplex operation.

All Qwest MOE customer 10/100/1000 Mbps Local Area Network (LAN) User-Network Interfaces (UNIs) as well as the internodal Gigabit Ethernet circuits will be provisioned for full duplex operation. Half duplex transmission mode is not a Qwest MOE service option.

2.7 Architecture

The baseline Qwest Metro Optical Ethernet (MOE) architecture is a distributed Layer 2 core and edge intelligent Ethernet switching topology with statistical multiplexing for shared data transport bandwidth over direct fiber or where available SONET facilities. The Qwest MOE physical network consists of point-to-point Gigabit Ethernet circuits or switch-to-switch links, while the logical or virtual network supports controlled customer access bandwidth with multipoint connectivity.

2.7.1 Physical Network

The Qwest MOE physical network architecture adapts to a wide diversity of enhanced transport technologies that exist in Qwest's Metropolitan Area Networks (MANs). Figure 2-2 presents a general example for delivery of Metro Optical Ethernet across multiple topologies and transport platforms. The Network Access Links or edge site/switch to core switch connections as well as the core switch to core switch Interoffice Facility (IOF) interconnections may be over:

- Direct fiber
- SONET 1+1 Linear, UPSR or 2F BLSR configurations
- Dense Wavelength Division Multiplexing (DWDM) or Optical Add-Drop Multiplexer (OADM) rings

Additionally, WDM or Ethernet over copper Network Access Link architectures may be used.

Qwest MOE traffic will typically be collected at the End-User premises by a Qwest-provided Layer 2 (L2) edge switch, which interfaces to customer-provided Data Terminal Equipment (DTE). There could be multiple customers on a single edge switch. These switches are then connected via Gigabit Ethernet uplinks and transported directly over fiber or Next Generation multiservice SONET Add-Drop Multiplexers (ADMs), where available or possibly WDM to the Qwest MOE core switching infrastructure.

The SONET ADM maps the Ethernet frames into a Synchronous Transport Signal (STS)-'24c' (or STS3c-7v) equivalent bandwidth or appropriate STS-Nc (or STSNc-Xv) Synchronous Payload Envelope (SPE) capacity to provide for Layer 1 protected transport via the Qwest SONET infrastructure. The Ethernet frames are then forwarded unmodified to the appropriate core switch. The encapsulation and transport do not affect information in the headers and IEEE 802.1Q VLANs are tunneled.

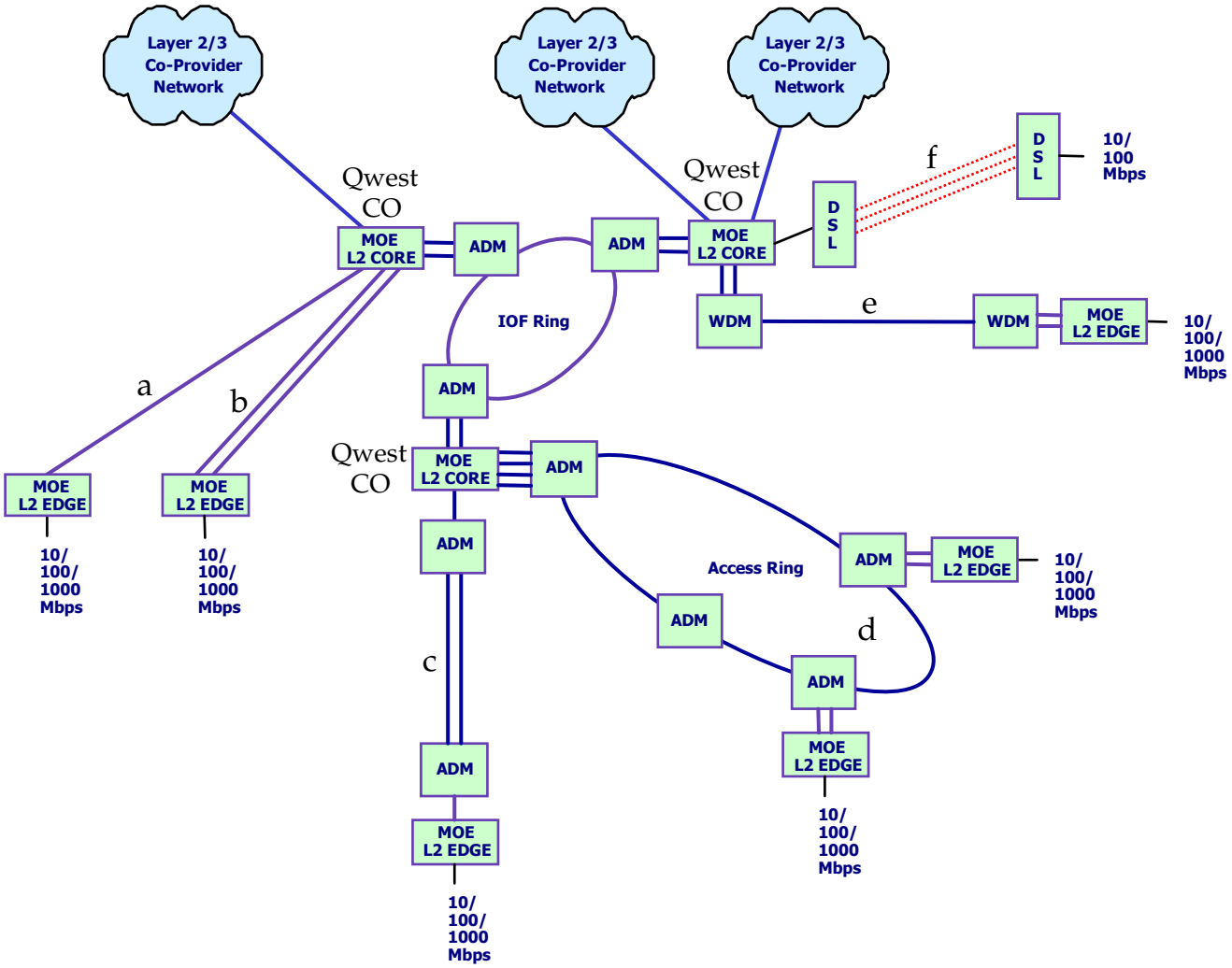
The Qwest SONET network will be used where available to connect the Layer 2 paths to form a Layer 2 switching network over SONET. The multiservice SONET ADMs employ Next Generation Gigabit Ethernet port cards to encapsulate the customers' Ethernet traffic for transport between the edge and core switches as well as from Qwest Central Office (CO) core switch to CO core switch in the interoffice. The Gigabit Ethernet core aggregation and edge intelligent Ethernet switches are sized to operate at wire speed while the standard logical Layer 2 network will be used to manage the shared MOE transport bandwidth.

Typical direct fiber, Ethernet-over-SONET (EoS) or copper and WDM physical Network Access Link (NAL) architectures are shown in Figure 2-2. At the center of the diagram are the Qwest MOE Layer 2 (L2) core switches, which aggregate the MOE traffic from all the End-User customer locations and interconnect to other Carriers or Layer 2/3 co-providers' networks via Gigabit Ethernet links. The core switches reside in Qwest COs, which are MOE Serving Wire Centers (SWCs) designated as entry or Service Points into the Qwest MOE network. Other COs listed by Qwest as MOE Service Points will backhaul customer traffic to the nearest core switch facility.

The Layer 2 edge switches may reside at End-User premises or be deployed within some Qwest COs as an aggregation device; while MOE User-Network Interfaces (UNIs) may be delivered to Interexchange Carrier (IC) or Internet Service Provider (ISP) defined Points of Presence (POPs) via direct core switch connections. Both core and edge switches perform statistical multiplexing, traffic separations, policing and marking. At the ingress, the switch checks for errors on a received packet, determines the destination port, stores the packet in shared memory and then forwards the packet to the destination port.

As indicated in Figure 2-2, depending upon the customer demand requirements and Qwest Local Loop infrastructure, different architectures may be used to provide the Ethernet NALs or customer-designated edge sites to Qwest MOE Layer 2 core switch connections.

Figure 2-2 Qwest MOE Physical Network



LEGEND

= Single-Mode Fiber Pair
= Copper Pair
ADM = SONET Add-Drop Multiplexer
WDM = Wavelength Division Multiplexer
DSL = Digital Subscriber Line Modem
Layer 2/3 Co-Provider Network = IC or ISP

2.7.2 Network Access Links

Network Access Links (NALs) are the Qwest-provided connections to the Qwest MOE network from the User-Network Interface (UNI) locations at an End-User premises, IC or ISP POP to the Qwest MOE core switching infrastructure. As indicated in Figure 2-2, the Qwest MOE customer UNI connects to the Qwest Metro Optical Ethernet network via several types of NAL physical network architectures. The edge switches are connected back to a Qwest MOE core switch at the Service Point or local Serving Wire Center via 1 Gbps (2 Gbps bi-directional) full duplex, point-to-point Ethernet circuits over direct fiber or SONET, where available or possibly via Wavelength Division Multiplexing (WDM). 10Base-T UNIs with a 5 or 10 Mbps bandwidth profile/NAL as well as 100Base-TX UNIs with a 10 or 20 Mbps bandwidth profile/NAL may also be delivered to a customer premises via standard IEEE 802.3ah Ethernet over bonded copper pairs using enhanced G.SHDSL modems. Network Access Link architectures are currently not a customer-specified option.

Qwest MOE is an Individual Case Basis (ICB) designed service and as such will follow the standard Auto Quote Contract Billing (AQCB®) System Design Center (SDC) process to determine the architecture that will best meet each customer's requirements based on the existing Qwest MOE infrastructure. Although there are several Network Access Link architectures, all of the following designs (see Figure 2-2, Qwest MOE Physical Network) meet the Qwest MOE requirements and may be used to provide the service.

- All edge switch to core switch connections are Gigabit Ethernet using one or more Single-Mode Fiber (SMF) pairs. Fiber redundancy (and diversity) will be provided where available, i.e. where such facilities exist in the Qwest Local Loop infrastructure. Customer sites served by copper facilities will be connected to the MOE core network using 10/100Base-T interfaces and Category 5 cabling.
- Although not shown, the User-Network Interface (UNI) will be at an RJ-45 jack on a Qwest-provided Category 5 Patch Panel for electrical, and a duplex FC-PC or SC connector on a Qwest-provided Fiber Distribution Panel (FDP) for optical Gigabit Ethernet interfaces. See Chapter 3, Network Interfaces for further information.

a) *Edge switch single homed to core switch over direct fiber (single pair)*

- The customer interfaces available via the Qwest MOE Layer 2 edge switches are 10Base-T, 100Base-TX and 1000Base-T electrical as well as 1000Base-LX (1300-1310 nm, SMF) and 1000Base-SX (850 nm, MMF) optical.
- Customers desiring a physical 10 or 100 Mbps optical LAN interface for example will need to use a media converter. Currently, media converters are not a Qwest MOE service option and must be Customer Provided Equipment (CPE).

b) *Edge switch dual homed to core switch over direct fiber (two pairs) using (Cisco) EtherChannel or standard IEEE 802.3-2002 (802.3ad) Link Aggregation Control Protocol (LACP) for uplink redundancy and Layer 2 load balancing*

- The operation of Link Aggregation Control Protocol (LACP) provides for recovery of connectivity following the failure of a Gigabit Interface Converter (GBIC) transceiver card or fiber. Currently, Link Aggregation (or Spanning Tree Protocol) is solely internal to the Qwest MOE network and is not a service option on customer facing switch ports at the User-Network Interface.
- LACP allows for Layer 2 load sharing on redundant Gigabit Ethernet uplinks to efficiently utilize the extra capacity inherent in this redundant design.
- Diverse facilities are not required.

c) *Edge switch single homed to core switch over SONET ADMs*

- Point-to-point Ethernet circuit over a 1+1 Linear, UPSR or 2F BLSR configuration.
- Provides low latency transport of full line rate Gigabit Ethernet traffic.
- Each Gigabit Ethernet port maps to a contiguous concatenated Synchronous Transport Signal (STS) circuit.
- Ethernet frames are transparently mapped into the SONET Super Rate payload.
- The SONET network provides encapsulation and Layer 1 protected transport of Ethernet traffic only (no Layer 2 switching).

d) *Edge switch dual homed to core switch over a SONET ring using (Cisco) EtherChannel or Link Aggregation Control Protocol (LACP) for uplink redundancy and Layer 2 load balancing*

- End-to-end link redundancy is provided by provisioning two Ethernet circuits from each edge switch across the SONET network to the CO core switch.
- Running LACP on the Ethernet links between each edge and core switch over the SONET ring provides for Layer 2 rerouting of customer traffic in case of a failure.

e) *Edge switch 'dual homed' to core switch over WDM using LACP for uplink redundancy and Layer 2 load balancing*

- Shown is a two channel (1310/1550 nm) passive Wavelength Division Multiplexing (WDM) system.
- Two uplinks for edge switch 'dual homed' to core switch over a single fiber pair.
- The operation of LACP provides for recovery of connectivity following the failure of a Gigabit Interface Converter (GBIC) transceiver card or single fiber. LACP allows for load sharing between the two Gigabit Ethernet circuits or 1310 and 1550 nm connections.
- Provides ultra low latency protected transport of full line rate Gigabit Ethernet traffic.
- A point-to-point Dense WDM (DWDM) system or an Optical Add-Drop Multiplexer (OADM) ring may also be used for Layer 1 transport if available in the Qwest MOE network infrastructure.

f) *Direct core switch connection using DSL modems over copper*

- 10Base-T or 100Base-TX Ethernet interfaces only.
- New Ethernet First Mile (EFM) PHY level standard IEEE 802.3ah-2004 (Amendment to IEEE Std 802.3-2002) bonding of up to 8 copper cable pairs using G.SHDSL.bis line code
- Supports bandwidth profiles or throughput up to a maximum of 20 Mbps symmetrical
- Deployment based on customer requirements, copper pair availability and loop distance
- 'Hitless' cut line protection

2.7.3 Core Switch Connections

The Gigabit Ethernet connections between the Qwest MOE Layer 2 core switches may be provided over direct fiber, SONET or DWDM/OADM. SONET facilities will be used where available and depending upon the number of Qwest COs, multiple direct fiber connections, SONET rings and/or DWDM/OADM systems may be required. The core switch Interoffice Facilities (IOF) architecture may be (in order of preference) full mesh, partial mesh, ring (mesh) or linear including hub and spoke.

In Figure 2-2, the three Qwest MOE Layer 2 core switches are shown as an example connected together in a full mesh via a single SONET ring. Each Qwest CO core switch connects directly to each of the other two core switches with a point-to-point Gigabit Ethernet circuit on the ring. Different scenarios are also possible for the MOE core switch interconnections. For example, there could be more than three Qwest CO sites in a metro region or more than one core switch per CO.

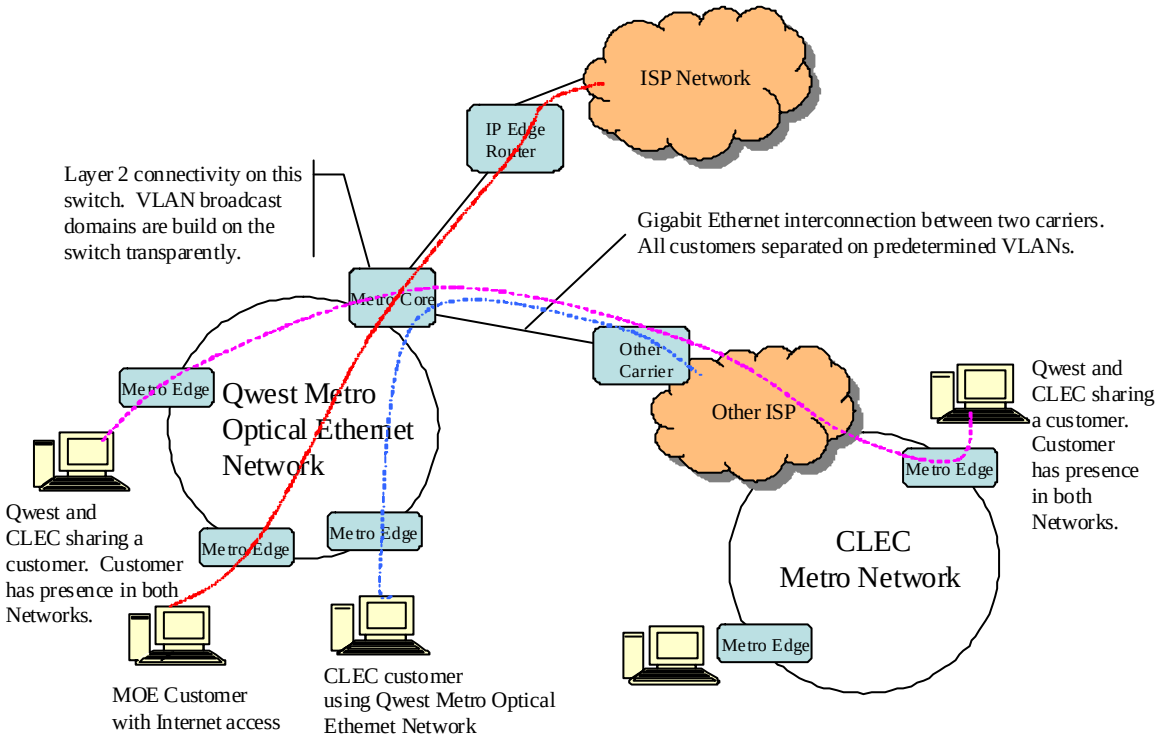
Regardless of the specific Qwest MOE core switch architecture, protection will be provided via Layer 1 transport redundancy and Ethernet Layer 2 control protocols on the Gigabit Ethernet IOF links. The primary requirement is that in case of a single link failure in the core switch network, no Qwest CO site will be isolated. There will always be either another parallel Gigabit Ethernet connection or an alternate path to get from core switch to core switch.

Per-VLAN Spanning Tree (PVST) will be run on the redundant/alternate path Gigabit Ethernet connections in the core switch IOF network to provide for Layer 2 rerouting of customer traffic in case of a failure. This design ensures high availability of the Qwest MOE core switch to core switch connections.

2.7.4 Carrier Interconnection

As shown in Figure 2-3, the MOE core switches are the designated connection points to Interexchange Carriers (ICs), Internet Service Providers (ISPs) and other co-provider's networks. Gigabit Ethernet User-Network Interfaces will be used to connect to other Carriers in a metro. A standard set of VLANs will be agreed upon between the Carriers for the purpose of exchanging Ethernet traffic but no Layer 3 information. All VLANs will be rate-limited both in the ingress (entry) and egress (exit) directions.

Figure 2-3 Carrier Interconnection



2.8 Resiliency

The following is in addition to the physical redundancy, and Layer 1 and Layer 2 protection protocols described in Sections 2.7.2, Network Access Links and 2.7.3, Core Switch Connections.

2.8.1 Edge Switches

The Qwest MOE edge switches will be deployed with the features below in order to maximize network uptime and prevent loss of customer traffic:

- Per-port broadcast, multicast, and unicast storm control to prevent faulty end stations from degrading overall Qwest MOE network performance.
- Switch port auto-recovery automatically attempts to re-enable a link that becomes disabled due to a network error.

An Uninterruptible Power Supply (UPS) with approximately 4 hours battery backup and 2 to 4 milliseconds switch time to safeguard against power outages may also be provided except in cases such as when waived by the customer.

2.8.2 Core Switches

To ensure high service availability for mission-critical applications, all Qwest MOE core switches will be deployed with the following features:

- Fully redundant (1+1) DC input, load-sharing power supplies.
- Standby Switch Fabric Module (1+1).
- Redundant clock modules.
- Redundant voltage termination modules.
- All modules and fan assemblies are hot-swappable, and can be added, replaced, or removed without interrupting the system power or causing other software or interfaces to shut down.
- (Cisco) EtherChannel or standard IEEE 802.3-2002 (802.3ad) Link Aggregation Control Protocol (LACP) enhances fault tolerance and offers higher-speed aggregated bandwidth and load balancing on multiple parallel Gigabit Ethernet core switch connections.

Furthermore, the core switches may be configured with:

- Redundant, hot-swappable supervisor engines with 1 to 3 second stateful failover enabling near-hitless software upgrades.
- Redundant supervisor engine in standby mode.

2.9 VLANs

A Virtual LAN (VLAN) is a switched network that connects two or more customer locations or User-Network Interfaces (UNIs) and:

- Enables the transfer of Ethernet frames between locations that are connected by the same VLAN.
- Prevents data transfer between customer locations or UNIs that are not part of the same VLAN.

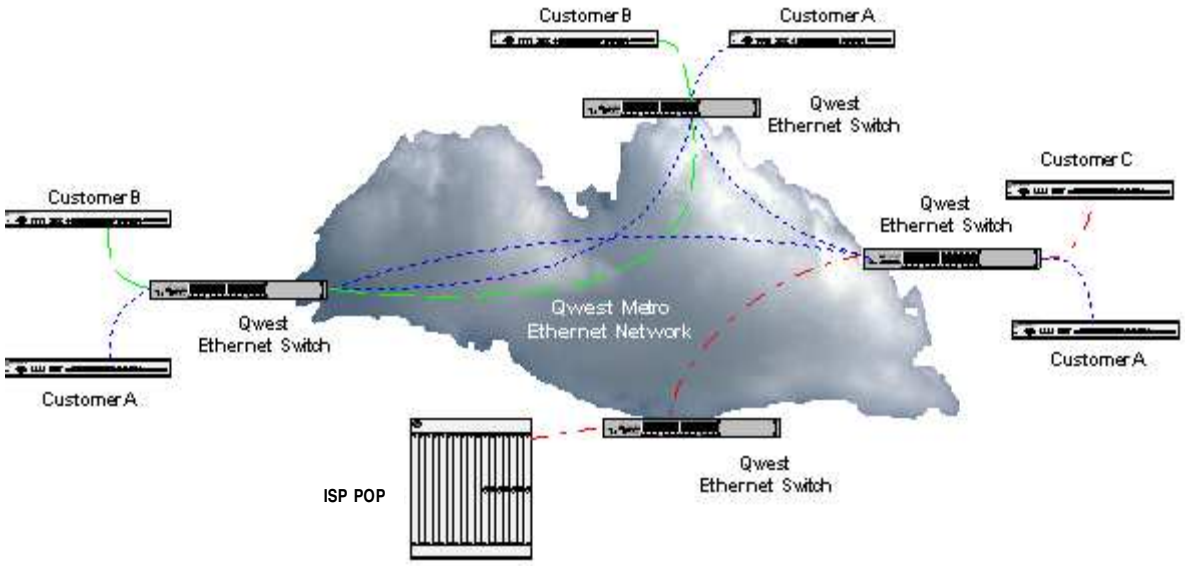
The function of a VLAN is to isolate the Layer 2 Media Access Control (MAC) broadcast domains. In order to provide data privacy and security, each individual customer subnet will be separated from all other customers on a unique VLAN at the edge site/switch and across the Qwest MOE network. VLANs ensure that data packets are forwarded only to end stations within a specific subnet, thus reducing broadcast transmissions and allowing the Qwest MOE network to be shared between multiple customers within a metro.

2.9.1 VLAN Tags

In order to carry the traffic of more than one subnet down a single cable, IEEE 802.1Q, *Virtual Bridged Local Area Networks* defines an additional 4 bytes added to the standard 802.3 Ethernet frame. These additional bytes contain a VLAN Identifier (ID) or tag (and the 802.1p packet priority bits) for identifying standard Ethernet frames that belong to a particular VLAN.

VLAN tags will be used to separate and control Qwest MOE customer connectivity within a metro region. As shown in Figure 2-4, at the ingress Qwest Ethernet switch or entry point into the MOE network, each customer's Ethernet frames or packets will have a single Qwest-inserted VLAN tag to identify their rate-limited bandwidth provisioned within the physical Gigabit Ethernet trunk links. The Qwest MOE UNIs or Network Access Links at the End-User premises, or ISP POP for example will be assigned to and associated with the customer's VLAN in order to provide a point-to-point or multipoint Ethernet Layer 2 Virtual Private Network (VPN), or high speed Dedicated Internet Access (DIA) service.

Figure 2-4 VLANs



Currently, only one VLAN connection will be supported per End-User customer interface. If multiple Qwest MOE services or VLAN connections are desired at a single location, a separate physical UNI will be required for each. The separate physical connections may be on the same VLAN. High speed Ethernet UNIs for access to co-providers' networks such as Interexchange Carriers (ICs) or Internet Service Providers (ISPs) will be provisioned with multiple of their subscribers, who are Qwest MOE End-User customers, or VLANs on a single switch port.

The Layer 2 core switches aggregate all the tagged Ethernet traffic coming from the Qwest MOE Layer 2 edge switches across a metro region and build separate broadcast domains for each customer's service based on their individual VLAN tags. All Carrier traffic will be VLAN tagged and passed on 802.1Q trunked Gigabit Ethernet interfaces to IC's and ISP's routers, or Layer 2/3 co-providers' VPN devices.

2.9.2 VLAN Stacking

VLAN stacking, also referred to as Q-in-Q (802.1Q in 802.1Q), is a technique whereby a second VLAN tag is inserted into the Ethernet frame header so that overlapping VLAN IDs can be supported across a network. Qwest MOE service is capable of 'stacking' a customer's VLAN tag or IEEE 802.1Q fields into the Qwest-inserted VLAN tag, thus enabling customers the capability of a Layer 2 VPN.

For End-User customers, VLAN stacking is done in which the customer facing switch port operates in a transparent mode and any traffic being sent by the customer, including VLAN tags and the Class of Service (CoS)/802.1p packet priority bits will be tunneled across the Qwest MOE network.

At the ingress UNI, an additional 802.1Q header with tag is added to the Ethernet frame. The Qwest MOE network will make its forwarding decisions based on this additional header. Once the frame arrives at the egress UNI, the outer or Qwest-inserted VLAN header is then discarded for handoff to the customer at the far end. Thus, an End-User customer can configure and extend their VLANs across the Qwest MOE network without the need to coordinate with Qwest. As stated in Section 2.7.4, Carrier Interconnection a standard set of VLAN IDs or tags will be agreed upon between Qwest, ICs, ISPs and other co-providers.

2.9.3 VLAN Tags and Customer Access Port Types

Table 2-1 lists the customer UNI and VLAN tag service attributes for the different customer access port options.

Table 2-1 Customer VLAN Tags and Access Ports

UNI & VLAN Service Attribute	Customer Access Port		
	Non – TLS	**TLS/TLS Plus**[1]	**Service Provider**[2]
Customer VLAN ID/Tag Preservation	N/A, customer does not send tagged traffic	Yes for UNIs within the same Qwest-inserted VLAN[3], also supports untagged Ethernet frames	Yes[4]
Service Multiplexing[5]	No	No	Yes
Customer VLAN ID/Tag Mapping	N/A, customer does not send tagged traffic	All customer VLANs are mapped to a single Qwest-inserted VLAN tag	No, Service Provider VLAN IDs must match Qwest VLAN IDs/tags
Bundling	Yes, All untagged Ethernet frames are mapped to a single Qwest VLAN, i.e. All to One Bundling only	Yes, all customer tagged (or untagged) traffic is mapped to a single Qwest VLAN, i.e. All to One Bundling only	No
Ingress Bandwidth Profile Per Ingress UNI[6]	Yes	Yes	No
Ingress Bandwidth Profile Per VLAN[6]	No	No	Yes (per Qwest VLAN ID)
Layer 2 Control Protocol Processing	N/A	Cisco Discovery Protocol (CDP), Spanning Tree Protocol (STP) and VLAN Trunking Protocol (VTP), and with TLS Plus Link Aggregation Control Protocol (LACP) or Cisco Port Aggregation Protocol (PAgP)[7] are tunneled	CDP, STP and VTP are disabled

Table 2-1 Notes:

1. TLS Plus is an option, where available in the Qwest network and requires the customer to order multiple parallel, (full duplex) point-to-point links operating at the same data rate, and is only offered on MOE with full line rate Fast Ethernet (100Base-TX) or Gigabit Ethernet (1000Base-T/LX/SX) ports. Consult with Qwest engineering for specific details including availability.
2. Generally available to Service Providers
3. VLANs are transparent with no constraint on the customer's choice of VLAN ID or the number of VLAN IDs that can be used at the UNI.
4. See Section 2.7.4 Carrier Interconnection for further information.
5. Service Multiplexing is the support of multiple Qwest-inserted VLAN tags at a single UNI. See Section 2.9.1 VLAN Tags for further information.
6. See Section 2.5 Rate-Limiting and Committed Information Rate for further information.
7. Load balancing is the responsibility of the customer with Link Aggregation failover times dependent upon their CPE configuration and protocol. See IEEE 802.3-2002, clause 43 and applicable vendor, e.g. Cisco documentation for further information.
8. TLS = Transparent LAN Service
9. N/A = Not Applicable

Table 2-2 shows the compatibility between the different customer access ports when provisioned as part of the same MOE service or Qwest VLAN.

Table 2-2 Access Port Compatibility

Port Type	Non – TLS	TLS/TLS Plus	Service Provider
Non – TLS	Yes	Not recommended[1]	Yes[2]
TLS/TLS Plus	Not recommended[1]	Yes	Yes[3]
Service Provider	Yes[2]	Yes[3]	See note 4

Notes:

1. Untagged traffic only, tagged Ethernet frames will be discarded
2. Typical DIA service application for passing untagged customer traffic to an ISP
3. Typical application for passing tagged End-User traffic to an Ethernet service or Layer 2 co-provider, who would be responsible for discarding the outer or Qwest-inserted VLAN tag
4. If a Service Provider wants to move traffic to another Service Provider, a TLS/TLS Plus port to TLS/TLS Plus port connection would be recommended for tunneling the Service Providers' VLAN IDs through the Qwest MOE network.

2.10 Ethernet Frame Formats

Qwest MOE service supports customer traffic with the following standard Ethernet frame formats:

- IEEE 802.3 including the Logical Link Control (LLC) Header as described in ISO/IEC 8802-2: 1998, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical Link Control*
- Ethernet Version II as released by the DIX (Digital Equipment Corporation/ Intel/Xerox) consortium

The following Ethernet frame formats are not supported and should be considered incompatible with Qwest MOE service:

- 802.3 SNAP (w/Sub-Network Access Protocol Header)
- Novell (NetWare) Proprietary or "802.3 Raw"

Qwest MOE service supports standard Ethernet frame sizes up to the IEEE 802.3/802.1Q maximum untagged/VLAN tagged frame size of 1518/1522 bytes. See Section 4.6, Packet Loss for further customer Ethernet frame requirements.

With Qwest Metro Optical Ethernet service, the customers' Ethernet frames will be delivered with the Ethernet MAC addresses and frame contents unchanged, i.e. the frames will remain intact from source to destination(s) across the Qwest MOE network. Customers' unicast, multicast and broadcast frames will be forwarded only to end stations within each customer's VLAN. The maximum number of MAC addresses that can be supported per customer Layer 2 device, i.e. Ethernet CPE is currently limited to 600 per switch port/UNI.

2.11 Layer 2/3 Protocol Tunneling

The following Layer 2 control protocols may be tunneled across each customer's VLAN or transparently transported over the Qwest MOE network:

- IEEE 802.3x MAC Control Frames
- IEEE 802.1p packet priority bits

Customer's Layer 3 IP routing, data packets or networking protocol(s) such as Border Gateway Protocol (BGP) will be transparent to the Qwest MOE network. Any Layer 3 protocol that can be encapsulated and transported over Ethernet, such as IP or IPX can be transported over the Qwest MOE network. See Section 2.9.3 VLAN Tags and Customer Access Port Types for further information.

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3. Network Interfaces

3.1 Applicability of Technical Specifications

Technical specifications presented in this chapter are applicable to Qwest® Metro Optical Ethernet® (MOE) service only. This document does not attempt to describe the equipment used to provide this service.

3.2 Description of Qwest MOE Network Interfaces

Qwest Metro Optical Ethernet (MOE) service will be provisioned using intelligent Ethernet switches. This technology allows Qwest to deliver the standard 10/100/1000 Mbps Local Area Network (LAN) interfaces shown in Table 3-1. A detailed description of these Ethernet protocols can be found in documents available from the Institute of Electrical and Electronics Engineers' (IEEE®'s) web site at: http://standards.ieee.org/.

Qwest MOE Network Access Links are provided to both End-User and Carrier customers. The signal characteristics and supported MAC Layers at the Network Interface (NI) will be as specified in the IEEE 802®.3-2002, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications* standard. The physical NI for all customers will be at an RJ-45 jack on a Qwest-provided Category 5 Patch Panel for electrical, and a duplex FC-PC or SC connector on a Qwest-provided Fiber Distribution Panel (FDP) for optical Gigabit Ethernet interfaces. SC connectors are an option, where available at customer premises locations only. The NI or User-Network Interface (UNI) is the point of demarcation between Qwest MOE service and the customer-provided Data Terminal Equipment (DTE).

Table 3-1 Available Interfaces

Interface	Bit Rate	Bandwidth Profile or Data Rate	Mode	Impedance or Central Wavelength	Cable or Fiber Type	Connector
10Base-T	10 Mbps	5, 10	Full duplex	100 ohms	Two pairs[1] of twisted-pair telephone or Category 3, 4 or 5 (recommended[2]) copper wire	RJ-45
100Base-TX	100 Mbps[4]	10, 20, 30, 40, 50, 60, 70, 80, 90, 100	Full duplex	100 ohms	Two pairs[1] of Category 5 Unshielded Twisted-Pair (UTP) or Shielded Twisted-Pair (STP) copper wire	RJ-45
1000Base-T	1000 Mbps[4]	10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000	Full duplex	100 ohms	Four pairs of Category 5 balanced copper cabling	RJ-45
1000Base-LX	1000 Mbps[4]	10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000	Full duplex	1300-1310 nm	One pair of Single-Mode Fiber	Duplex FC-PC, or SC
1000Base-SX	1000 Mbps[4]	10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000	Full duplex	850 nm	One pair of Multi-Mode Fiber	Duplex FC-PC, or SC

Table 3-1 Notes:

1. While 10Base-T and 100Base-TX compatible devices can use a two twisted-pair cable, Qwest will wire all 10/100/1000 Mbps electrical switch ports to the User-Network Interface (UNI) with a four twisted-pair cable and terminate on standard RJ-45 connectors. Only the pinouts will be different for 10/100 Mbps ports since just 4 of the 8 wires or RJ-45 connector pins are used.
2. Although the customer may use Category 3, 4 or 5 copper wire when connecting to 10Base-T ports, Qwest will use Category 5 balanced copper cabling from the Qwest MOE switch port to the Category 5 Patch Panel UNI for all electrical interfaces.
3. Given the above, remote upgrades from 10Base-T to 100Base-TX to 1000Base-T on existing electrical interfaces may be possible for Qwest MOE customers (when delivered directly from an Ethernet switch port). See Section 4.2.2, Bandwidth Change Requests for further information.
4. The actual signaling rate for 100Base-TX and 1000Base-T/LX/SX Network Interfaces is 125 Mbps and 1250 Mbps respectively.
5. Qwest will manually provision the speed and full duplex transmission mode on all 10/100/1000 Mbps MOE customer facing electrical switch ports. Auto-negotiating and flow control will only be enabled at the UNI for optical Gigabit Ethernet ports.
6. Multiple interfaces using IEEE 802.3ad Link Aggregation or, 802.1d, 802.1w Rapid or 802.1s Multiple Spanning Tree Protocol for increased bandwidth and/or link redundancy/load balancing are currently not Qwest MOE service options at the UNI. See Section 2.11, Layer 2/3 Protocol Tunneling for further information on customer applications of Spanning Tree Protocol.
7. nm = nanometer
8. Single-Mode Fiber is 9 or 10/125 micron.
9. Multi-Mode Fiber is 50 or 62.5/125 micron; see Table 3-9 for distance limitations.
10. FC-PC (Fiber Connector - Physical Contact) is a keyed, locking type of fiber optic connector with a round barrel and threaded retaining ring.
11. SC (Subscriber Connector) is a push-pull type of fiber optic connector with a square barrel that conforms to ISO/IEC 11801: 2002, *Information technology - Generic cabling for customer premises*.

3.3 Connecting to 10Base-T, 100Base-TX and 1000Base-T Network Interfaces

The Qwest MOE 10/100/1000 Mbps electrical interfaces use standard RJ-45 connectors at the User-Network Interface (UNI). Table 3-2 shows the pinouts.

Table 3-2 10/100/1000 Mbps Electrical UNI RJ-45 Pinouts

Pin	Label
1	TP0+
2	TP0-
3	TP1+
4	TP2+
5	TP2-
6	TP1-
7	TP3+
8	TP3-

Qwest will always use a straight-through cable to connect to the Category 5 Patch Panel for electrical UNIs and the customer will use either a straight-through or crossover cable depending upon the equipment they are connecting to the UNI. For connecting to servers, workstations and routers a straight-through cable is required, and for switch connections a crossover cable is required. The UNI associated with Qwest Metro Optical Ethernet for LAN interconnection will not provide the repeater functionality as described in IEEE 802.3-2002.

When connecting to 10Base-T and 100Base-TX compatible devices, the customer can use a two or four twisted-pair cable. Table 3-3 shows the two twisted-pair, straight-through cable and Table 3-4 shows the four twisted-pair, straight-through cable RJ-45 connections at the UNI. Table 3-5 shows the two twisted-pair, crossover cable and Table 3-6 shows the four twisted-pair, crossover cable RJ-45 connections at the UNI.

Table 3-3 Two Twisted-Pair Straight-Through Cable RJ-45 Connections for 10/100 Mbps Electrical UNIs

RJ-45	RJ-45
1 RD+	1 TD+
2 RD–	2 TD–
3 TD+	3 RD+
6 TD–	6 RD–

Table 3-4 Four Twisted-Pair Straight-Through Cable RJ-45 Connections for 10/100 Mbps Electrical UNIs

RJ-45	RJ-45
1 RD+	1 TD+
2 RD-	2 TD-
3 TD+	3 RD+
6 TD-	6 RD-
4 NC	4 NC
5 NC	5 NC
7 NC	7 NC
8 NC	8 NC

Table 3-5 Two Twisted-Pair Crossover Cable RJ-45 Connections for 10/100 Mbps Electrical UNIs

RJ-45	RJ-45
1 RD+	3 TD+
2 RD–	6 TD–
3 TD+	1 RD+
6 TD–	2 RD–

Table 3-6 Four Twisted-Pair Crossover Cable RJ-45 Connections for 10/100 Mbps Electrical UNIs

RJ-45	RJ-45
1 RD+	3 TD+
2 RD-	6 TD-
3 TD+	1 RD+
6 TD-	2 RD-
4 NC	4 NC
5 NC	5 NC
7 NC	7 NC
8 NC	8 NC

When connecting to 1000Base-T compatible devices, the customer must use a four twisted-pair Category 5 (or better) cable. Table 3-7 shows the straight-through cable and Table 3-8 shows the crossover cable RJ-45 connections at the UNI.

Table 3-7 Four Twisted-Pair Straight-Through Cable RJ-45 Connections for 10/100/1000 Mbps Electrical UNIs

RJ-45	RJ-45
1 TP0+	1 TP1+
2 TP0-	2 TP1-
3 TP1+	3 TP0+
6 TP1-	6 TP0-
4 TP2+	4 TP3+
5 TP2-	5 TP3-
7 TP3+	7 TP2+
8 TP3-	8 TP2-

Table 3-8 Four Twisted-Pair Crossover Cable RJ-45 Connections for 10/100/1000 Mbps Electrical UNIs

RJ-45	RJ-45
1 TP0+	3 TP1+
2 TP0-	6 TP1-
3 TP1+	1 TP0+
6 TP1-	2 TP0-
4 TP2+	7 TP3+
5 TP2-	8 TP3-
7 TP3+	4 TP2+
8 TP3-	5 TP2-

3.4 Distance Limitations

The maximum supported cable length from the Qwest MOE switch port to (active) Customer Provided Equipment shall be as listed in Table 3-9. Although it's assumed that in most cases the subtended equipment will be co-located with the MOE edge switch at a customer site, all Network Interfaces should be jointly engineered between Qwest and the customer.

Table 3-9 Maximum Distance from the User-Network Interface[1]

Interface	Impedance or Central Wavelength	Cable or Fiber Type	Modal bandwidth (MHz/km)	Maximum Distance
10Base-T	100 ohms	Two pairs of twisted-pair telephone or Category 3, 4 or 5 (recommended) copper wire	N/A	100 meters (328 feet)
100Base-TX	100 ohms	Two pairs of Category 5 Unshielded Twisted-Pair (UTP) or Shielded Twisted-Pair (STP) copper wire	N/A	100 meters (328 feet)
1000Base-T	100 ohms	Four pairs of Category 5 balanced copper cabling	N/A	100 meters (328 feet)
1000Base-LX	1300-1310 nm	One pair of Single-Mode Fiber	N/A	10 kilometers (6.2 miles)
1000Base-SX	850 nm	One pair of 50 micron Multi-Mode Fiber	400	500 meters (1,640 feet)
			500	550 meters (1,804 feet)
		One pair of 62.5 micron Multi-Mode Fiber	160	220 meters (722 feet)
			200	275 meters (902 feet)

Notes:

1. Including cable from Qwest switch port to UNI
2. N/A = Not Applicable
3. nm = nanometer
4. Single-Mode Fiber is 9 or 10/125 micron.

Copper cables, Single-Mode Fiber (SMF) or Multi-Mode Fiber (MMF) jumpers to connect the Customer Provided Equipment (CPE) to the UNI on the Qwest Category 5 Patch Panel or Fiber Distribution Panel must be provided by the customer. These cables should be at least 2 meters long to facilitate attachment within the edge switch equipment frame. 2 meters is also the minimum supported cable distance from the Qwest Gigabit Interface Converter (GBIC) or customer facing switch port used to deliver 1000Base-LX UNIs.

3.5 1000Base-LX and 1000Base-SX Interface Power Levels

The Qwest MOE 1000Base-LX User-Network Interface fully complies with the IEEE 802.3-2002 (802.3z) 1000Base-LX standard. However, it has a higher optical quality which allows it to reach 10 kilometers (6.2 miles) over 1310 nm Single-Mode Fiber, compared with the 5 km (3.1 miles) specified in the IEEE standard. Table 3-10 lists the fiber loss budget from the Qwest MOE switch port to (active) Customer Provided Equipment for 1000Base-LX (1300-1310 nm, SMF) and 1000Base-SX (850 nm, MMF) UNIs.

Table 3-10 Fiber Loss Budget for 1000Base-LX and 1000Base-SX UNIs

Interface	Transmit (dBm)		Receive (dBm)	
	Max	Min	Max	Min
1000Base-LX	– 3	– 9.5	– 3	– 19
1000Base-SX	– 4	– 9.5	0	– 17

Note: Based on any valid 8-bit/10-bit code pattern at the User-Network Interface

It's the transmitting party's responsibility to achieve the minimum interface power. The optical power level at the User-Network Interface (FDP) shall meet the minimum transmit power listed in Table 3-10. Also, it's the responsibility of the receiving party to attenuate the optical signal level if required.

3.6 Network Channel (NC) and Network Channel Interface (NCI) Codes

NC and NCI Codes convey service and technical parameters. The following sections explain the codes in a general manner and also provide specific codes to aid in ordering the User-Network Interfaces and Network Access Links for Qwest MOE service. The NC and NCI Codes are to be provided by the customer to the Qwest Service Representative at the time a request for new or upgrades to an existing service are initiated.

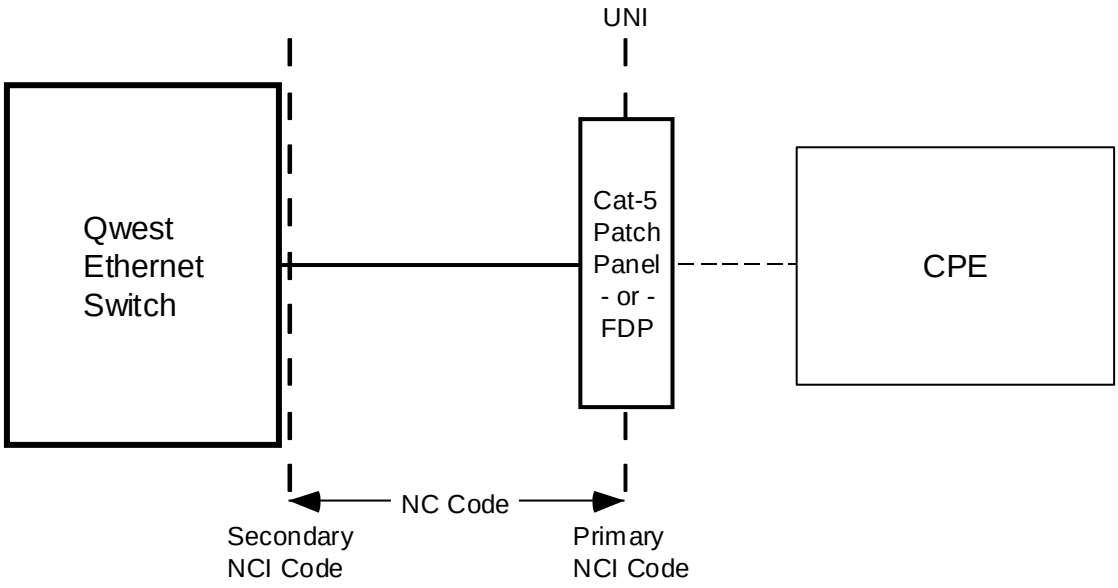
Additional information concerning NC/NCI Codes is available in ANSI T1.223-1997, *Information Interchange - Structure and Representation of Network Channel (NC) and Network Channel Interface (NCI) Codes for the North American Telecommunications System*.

In some instances Qwest service offerings differ from those described by Telcordia Technologies in their published Industry Support Interface: ISI-SR-STS 000307, *NC/NCI Code Dictionary*. Furthermore, definitions of NC and NCI Codes can change over time, therefore it's important to request Qwest Metro Optical Ethernet (MOE) service as defined in this publication.

Qwest MOE service is ordered and provisioned on a per port, per location basis and will be identified using standard NC/NCI Codes. Since the edge switches and Gigabit Ethernet uplinks between the edge site/switch and core switches as well as the core switch network interconnections are Qwest infrastructure, the MOE customer orders will only occur between the User-Network Interface (UNI) and Qwest edge (or core) Ethernet switch. Figure 3-1 shows where the NC, and Primary and Secondary NCI Codes apply to Qwest MOE service. As indicated in the figure, a Primary NCI Code/NC Code/Secondary NCI Code combination is required for each UNI or Qwest MOE Network Access Link location.

For Dedicated Internet Access (DIA), the Internet Service Provider (ISP) will order the Ethernet circuits or NALs from Qwest in order to connect to their subscribers, who are Qwest MOE End-User customers.

Figure 3-1 Qwest MOE NC and NCI Codes



LEGEND

CPE = Customer Provided Equipment
FDP = Fiber Distribution Panel
NC = Network Channel
NCI = Network Channel Interface
UNI = User-Network Interface

3.6.1 NC Code Function and Format

Primarily, service considerations are encoded into Network Channel (NC) Codes. Included in this code set are customer orderable options associated with the individual Ethernet channels or Network Access Links (NALs). When ordering Qwest MOE, the NC Code is specified by the customer to advise Qwest of the required service configuration of the NAL.

An NC Code consists of four alpha/numeric characters, which may include a dash (–). There are neither spaces nor delimiters between the characters. An NC Code has two data elements:

- The first two characters are the Channel Code, which for Qwest MOE identify the Ethernet service for each Network Access Link as 10, 100 or 1000 Mbps at the UNI.
- The last two characters are the Optional Feature Codes, which represent specific options available for each channel. Varying combinations of the third and fourth characters allow for further description of the type of service. For Qwest MOE, the third character defines full duplex transmission mode and the fourth character options indicate the bandwidth profile or throughput per NAL.

3.6.2 Qwest MOE NC Codes

Tables 3-11 to 3-13 list the Network Channel (NC) Codes for ordering Qwest Metro Optical Ethernet service.

Table 3-11 NC Codes for 10 Mbps Service

NC Code	Description
KPA5	Fractional 10 Mbps Ethernet, Full Duplex, 5 Mbps
KDA–	10 Mbps Ethernet, Full Duplex, electrical handoff

Table 3-12 NC Codes for 100 Mbps Service

NC Code	Description
KQA1	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 10 Mbps
KQA2	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 20 Mbps
KQA3	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 30 Mbps
KQA4	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 40 Mbps
KQA5	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 50 Mbps
KQA6	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 60 Mbps
KQA7	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 70 Mbps
KQA8	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 80 Mbps
KQA9	Fractional 100 Mbps Ethernet, Full Duplex – Rate based on Ethernet switch, 90 Mbps
KEA–	100 Mbps Ethernet, Full Duplex, electrical handoff

Table 3-13 NC Codes for 1000 Mbps Service

NC Code	Description
KRFB	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing[1], 10 Mbps
KRFD	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing, 20 Mbps
KRFF	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing, 30 Mbps
KRFH	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing, 40 Mbps
KRFJ	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing, 50 Mbps
KRFL	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing, 60 Mbps
KRFN	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing, 70 Mbps
KRFP	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing, 80 Mbps
KRFR	Ethernet, Rate-Adjustable 1 Gbps Ethernet (Full Duplex), Rate based on Ethernet Switch, Facility supporting EVC service multiplexing, 90 Mbps
KRA1	Rate-Adjustable Gigabit Ethernet (Point to Point[2] and full duplex), Rate based on Ethernet switch, 100 Mbps
KRA2	Rate-Adjustable Gigabit Ethernet (Point to Point and full duplex), Rate based on Ethernet switch, 200 Mbps
KRA3	Rate-Adjustable Gigabit Ethernet (Point to Point and full duplex), Rate based on Ethernet switch, 300 Mbps
KRA4	Rate-Adjustable Gigabit Ethernet (Point to Point and full duplex), Rate based on Ethernet switch, 400 Mbps
KRA5	Rate-Adjustable Gigabit Ethernet (Point to Point and full duplex), Rate based on Ethernet switch, 500 Mbps
KRA6	Rate-Adjustable Gigabit Ethernet (Point to Point and full duplex), Rate based on Ethernet switch, 600 Mbps
KRA7	Rate-Adjustable Gigabit Ethernet (Point to Point and full duplex), Rate based on Ethernet switch, 700 Mbps
KRA8	Rate-Adjustable Gigabit Ethernet (Point to Point and full duplex), Rate based on Ethernet switch, 800 Mbps
KRA9	Rate-Adjustable Gigabit Ethernet (Point to Point and full duplex), Rate based on Ethernet switch, 900 Mbps
KFL–	1 Gbps Ethernet

Table 3-13 notes:

1. While these NC codes can be used with any of the different customer access port types, EVC (Ethernet Virtual Connection) or VLAN service multiplexing is only provided on Service Provider ports as described in Section 2.9.3.
2. Point-to-point applies to the individual Gigabit Ethernet Network Access Links; however the Qwest MOE Layer 2 VPN service may be point-to-point or multipoint.

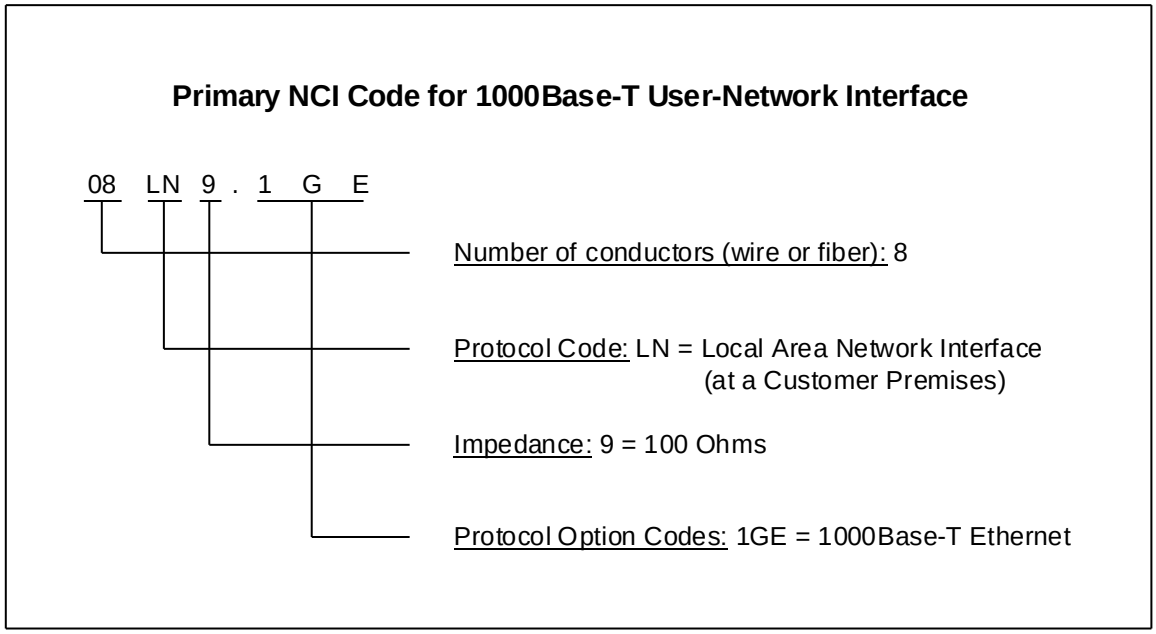
3.6.3 NCI Code Form and Components

The Network Channel Interface (NCI) Code provides the means to define the physical characteristics at the User-Network Interface (UNI) for the service order, design and circuit provisioning processes.

An NCI Code has the form 08LN9.1GE. The period between the characters is a delimiter, which is used for improved clarity and causes the subsequent Protocol Option Codes to stand out. An NCI Code has no dashes (–).

The Qwest MOE NCI Codes define the physical 10, 100 and 1000 Mbps electrical and optical customer interface options available with the service. Figure 3-2 illustrates the components of the Network Channel Interface Code with the subsequent definitions for a 1000Base-T UNI.

Figure 3-2 Qwest MOE NCI Code Example



3.6.4 Qwest MOE Primary NCI Codes

Tables 3-14 and 3-15 list the Primary Network Channel Interface (NCI) Codes for ordering Qwest Metro Optical Ethernet User-Network Interfaces (UNIs) at customer premises locations. A customer premises may be at an End-User or Access Carrier, e.g. Interexchange Carrier (IC) or Internet Service Provider (ISP) Point-of-Presence (POP).

Table 3-14 Primary NCI Codes for Electrical UNIs at a Customer Premises

NCI Code	Description
04LN9.10T	4 Conductors, Local Area Network Interface, 100 Ohms, 10Base-T Ethernet
04LN9.1CT	4 Conductors, Local Area Network Interface, 100 Ohms, 100Base-T Ethernet
08LN9.1GE	8 Conductors, Local Area Network Interface, 100 Ohms, 1000Base-T Ethernet

Table 3-15 Primary NCI Codes for 1000Base-LX and 1000Base-SX UNIs at a Customer Premises

NCI Code	Description
02LNF.A02	2 Conductors, Local Area Network Interface, Fiber, 1310 nm, Single-mode Fiber
02LNF.A04	2 Conductors, Local Area Network Interface, Fiber, 850 nm, 50 micron Multi-mode Fiber
02LNF.A07	2 Conductors, Local Area Network Interface, Fiber, 850 nm, 62.5 micron Multi-mode Fiber

3.6.5 Qwest MOE Secondary NCI Codes

As shown in Figures 3-1 and 3-3, a Secondary Network Channel Interface (NCI) Code applies at each Qwest Metro Optical Ethernet (MOE) switch port used to deliver a customer's Network Access Link (NAL). The Qwest MOE switch port is at the other, i.e. Qwest end of the Network Channel (NC) or NAL, whereas a Primary NCI Code applies at the UNI.

Tables 3-16 and 3-17 list the Secondary NCI Codes for ordering Qwest Metro Optical Ethernet service.

Table 3-16 Secondary NCI Codes for Electrical UNIs

NCI Code	Description
04CX9.10T	4 Conductors, Digital Termination On A Switch, 100 Ohms, 10Base-T Ethernet Switch Port
04CX9.1CT	4 Conductors, Digital Termination On A Switch, 100 Ohms, 100Base-T Ethernet Switch Port
08CX9.1GE	8 Conductors, Digital Termination On A Switch, 100 Ohms, Gigabit Ethernet Switch Port

Table 3-17 Secondary NCI Code for 1000Base-LX and 1000Base-SX UNIs

NCI Code	Description
02CXF.1GE	2 Conductors, Digital Termination On A Switch, Fiber, Gigabit Ethernet Switch Port

3.6.6 Qwest MOE NC/NCI Code Combinations

Figure 3-3 shows a Qwest MOE NC/NCI Code service order example for a 3 point customer premises Ethernet service, while Table 3-18 lists all the valid NC Code, Primary and Secondary NCI Code combinations for ordering Qwest Metro Optical Ethernet service.

Figure 3-3 Qwest MOE NC/NCI Code Service Order Example

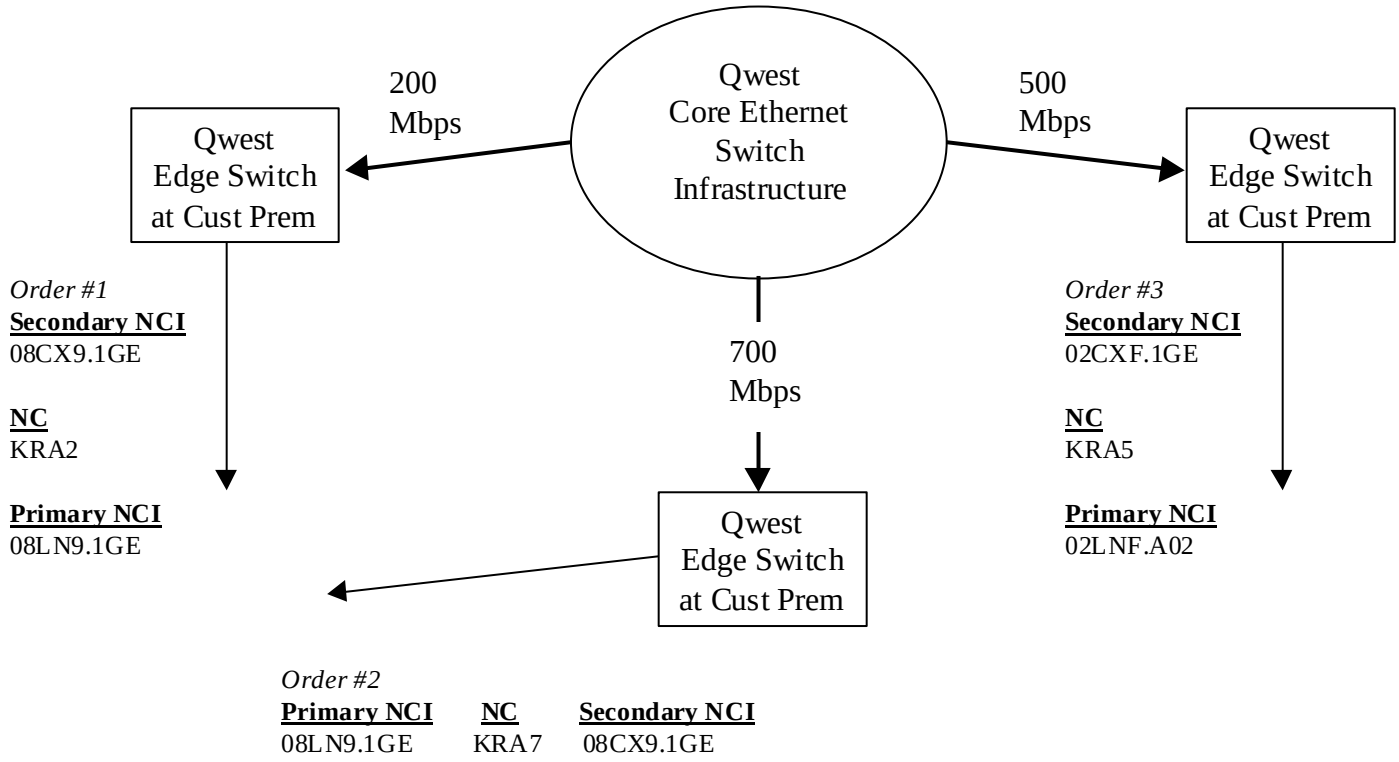


Table 3-18 NC Code, Primary and Secondary NCI Code Combinations

NC Code	Primary NCI Code	Secondary NCI Code	Physical Interface (Mbps)	Bandwidth Profile (Mbps)	User-Network Interface	User-Network Interface Location
KPA5	04LN9.10T	04CX9.10T	10	5	10Base-T	Customer Premises
KDA-	04LN9.10T	04CX9.10T	10	10	10Base-T	Customer Premises
KQA1	04LN9.1CT	04CX9.1CT	100	10	100Base-TX	Customer Premises
KQA2	04LN9.1CT	04CX9.1CT	100	20	100Base-TX	Customer Premises
KQA3	04LN9.1CT	04CX9.1CT	100	30	100Base-TX	Customer Premises
KQA4	04LN9.1CT	04CX9.1CT	100	40	100Base-TX	Customer Premises
KQA5	04LN9.1CT	04CX9.1CT	100	50	100Base-TX	Customer Premises
KQA6	04LN9.1CT	04CX9.1CT	100	60	100Base-TX	Customer Premises
KQA7	04LN9.1CT	04CX9.1CT	100	70	100Base-TX	Customer Premises
KQA8	04LN9.1CT	04CX9.1CT	100	80	100Base-TX	Customer Premises
KQA9	04LN9.1CT	04CX9.1CT	100	90	100Base-TX	Customer Premises
KEA-	04LN9.1CT	04CX9.1CT	100	100	100Base-TX	Customer Premises
KRFB	08LN9.1GE	08CX9.1GE	1000	10	1000Base-T	Customer Premises
KRFB	02LNF.A02	02CXF.1GE	1000	10	1000Base-LX (SMF)	Customer Premises
KRFB	02LNF.A04	02CXF.1GE	1000	10	1000Base-SX (50 um MMF)	Customer Premises
KRFB	02LNF.A07	02CXF.1GE	1000	10	1000Base-SX (62.5 um MMF)	Customer Premises
KRFD	08LN9.1GE	08CX9.1GE	1000	20	1000Base-T	Customer Premises
KRFD	02LNF.A02	02CXF.1GE	1000	20	1000Base-LX (SMF)	Customer Premises
KRFD	02LNF.A04	02CXF.1GE	1000	20	1000Base-SX (50 um MMF)	Customer Premises
KRFD	02LNF.A07	02CXF.1GE	1000	20	1000Base-SX (62.5 um MMF)	Customer Premises

Table 3-18 NC Code, Primary and Secondary NCI Code Combinations (Continued)

NC Code	Primary NCI Code	Secondary NCI Code	Physical Interface (Mbps)	Bandwidth Profile (Mbps)	User-Network Interface	User-Network Interface Location
KRFF	08LN9.1GE	08CX9.1GE	1000	30	1000Base-T	Customer Premises
KRFF	02LNF.A02	02CXF.1GE	1000	30	1000Base-LX (SMF)	Customer Premises
KRFF	02LNF.A04	02CXF.1GE	1000	30	1000Base-SX (50 um MMF)	Customer Premises
KRFF	02LNF.A07	02CXF.1GE	1000	30	1000Base-SX (62.5 um MMF)	Customer Premises
KRFH	08LN9.1GE	08CX9.1GE	1000	40	1000Base-T	Customer Premises
KRFH	02LNF.A02	02CXF.1GE	1000	40	1000Base-LX (SMF)	Customer Premises
KRFH	02LNF.A04	02CXF.1GE	1000	40	1000Base-SX (50 um MMF)	Customer Premises
KRFH	02LNF.A07	02CXF.1GE	1000	40	1000Base-SX (62.5 um MMF)	Customer Premises
KRFJ	08LN9.1GE	08CX9.1GE	1000	50	1000Base-T	Customer Premises
KRFJ	02LNF.A02	02CXF.1GE	1000	50	1000Base-LX (SMF)	Customer Premises
KRFJ	02LNF.A04	02CXF.1GE	1000	50	1000Base-SX (50 um MMF)	Customer Premises
KRFJ	02LNF.A07	02CXF.1GE	1000	50	1000Base-SX (62.5 um MMF)	Customer Premises
KRFL	08LN9.1GE	08CX9.1GE	1000	60	1000Base-T	Customer Premises
KRFL	02LNF.A02	02CXF.1GE	1000	60	1000Base-LX (SMF)	Customer Premises
KRFL	02LNF.A04	02CXF.1GE	1000	60	1000Base-SX (50 um MMF)	Customer Premises
KRFL	02LNF.A07	02CXF.1GE	1000	60	1000Base-SX (62.5 um MMF)	Customer Premises
KRFN	08LN9.1GE	08CX9.1GE	1000	70	1000Base-T	Customer Premises
KRFN	02LNF.A02	02CXF.1GE	1000	70	1000Base-LX (SMF)	Customer Premises
KRFN	02LNF.A04	02CXF.1GE	1000	70	1000Base-SX (50 um MMF)	Customer Premises
KRFN	02LNF.A07	02CXF.1GE	1000	70	1000Base-SX (62.5 um MMF)	Customer Premises

Table 3-18 NC Code, Primary and Secondary NCI Code Combinations (Continued)

NC Code	Primary NCI Code	Secondary NCI Code	Physical Interface (Mbps)	Bandwidth Profile (Mbps)	User-Network Interface	User-Network Interface Location
KRFP	08LN9.1GE	08CX9.1GE	1000	80	1000Base-T	Customer Premises
KRFP	02LNF.A02	02CXF.1GE	1000	80	1000Base-LX (SMF)	Customer Premises
KRFP	02LNF.A04	02CXF.1GE	1000	80	1000Base-SX (50 um MMF)	Customer Premises
KRFP	02LNF.A07	02CXF.1GE	1000	80	1000Base-SX (62.5 um MMF)	Customer Premises
KRFR	08LN9.1GE	08CX9.1GE	1000	90	1000Base-T	Customer Premises
KRFR	02LNF.A02	02CXF.1GE	1000	90	1000Base-LX (SMF)	Customer Premises
KRFR	02LNF.A04	02CXF.1GE	1000	90	1000Base-SX (50 um MMF)	Customer Premises
KRFR	02LNF.A07	02CXF.1GE	1000	90	1000Base-SX (62.5 um MMF)	Customer Premises
KRA1	08LN9.1GE	08CX9.1GE	1000	100	1000Base-T	Customer Premises
KRA1	02LNF.A02	02CXF.1GE	1000	100	1000Base-LX (SMF)	Customer Premises
KRA1	02LNF.A04	02CXF.1GE	1000	100	1000Base-SX (50 um MMF)	Customer Premises
KRA1	02LNF.A07	02CXF.1GE	1000	100	1000Base-SX (62.5 um MMF)	Customer Premises
KRA2	08LN9.1GE	08CX9.1GE	1000	200	1000Base-T	Customer Premises
KRA2	02LNF.A02	02CXF.1GE	1000	200	1000Base-LX (SMF)	Customer Premises
KRA2	02LNF.A04	02CXF.1GE	1000	200	1000Base-SX (50 um MMF)	Customer Premises
KRA2	02LNF.A07	02CXF.1GE	1000	200	1000Base-SX (62.5 um MMF)	Customer Premises
KRA3	08LN9.1GE	08CX9.1GE	1000	300	1000Base-T	Customer Premises
KRA3	02LNF.A02	02CXF.1GE	1000	300	1000Base-LX (SMF)	Customer Premises
KRA3	02LNF.A04	02CXF.1GE	1000	300	1000Base-SX (50 um MMF)	Customer Premises
KRA3	02LNF.A07	02CXF.1GE	1000	300	1000Base-SX (62.5 um MMF)	Customer Premises

Table 3-18 NC Code, Primary and Secondary NCI Code Combinations (Continued)

NC Code	Primary NCI Code	Secondary NCI Code	Physical Interface (Mbps)	Bandwidth Profile (Mbps)	User-Network Interface	User-Network Interface Location
KRA4	08LN9.1GE	08CX9.1GE	1000	400	1000Base-T	Customer Premises
KRA4	02LNF.A02	02CXF.1GE	1000	400	1000Base-LX (SMF)	Customer Premises
KRA4	02LNF.A04	02CXF.1GE	1000	400	1000Base-SX (50 um MMF)	Customer Premises
KRA4	02LNF.A07	02CXF.1GE	1000	400	1000Base-SX (62.5 um MMF)	Customer Premises
KRA5	08LN9.1GE	08CX9.1GE	1000	500	1000Base-T	Customer Premises
KRA5	02LNF.A02	02CXF.1GE	1000	500	1000Base-LX (SMF)	Customer Premises
KRA5	02LNF.A04	02CXF.1GE	1000	500	1000Base-SX (50 um MMF)	Customer Premises
KRA5	02LNF.A07	02CXF.1GE	1000	500	1000Base-SX (62.5 um MMF)	Customer Premises
KRA6	08LN9.1GE	08CX9.1GE	1000	600	1000Base-T	Customer Premises
KRA6	02LNF.A02	02CXF.1GE	1000	600	1000Base-LX (SMF)	Customer Premises
KRA6	02LNF.A04	02CXF.1GE	1000	600	1000Base-SX (50 um MMF)	Customer Premises
KRA6	02LNF.A07	02CXF.1GE	1000	600	1000Base-SX (62.5 um MMF)	Customer Premises
KRA7	08LN9.1GE	08CX9.1GE	1000	700	1000Base-T	Customer Premises
KRA7	02LNF.A02	02CXF.1GE	1000	700	1000Base-LX (SMF)	Customer Premises
KRA7	02LNF.A04	02CXF.1GE	1000	700	1000Base-SX (50 um MMF)	Customer Premises
KRA7	02LNF.A07	02CXF.1GE	1000	700	1000Base-SX (62.5 um MMF)	Customer Premises
KRA8	08LN9.1GE	08CX9.1GE	1000	800	1000Base-T	Customer Premises
KRA8	02LNF.A02	02CXF.1GE	1000	800	1000Base-LX (SMF)	Customer Premises
KRA8	02LNF.A04	02CXF.1GE	1000	800	1000Base-SX (50 um MMF)	Customer Premises
KRA8	02LNF.A07	02CXF.1GE	1000	800	1000Base-SX (62.5 um MMF)	Customer Premises

Table 3-18 NC Code, Primary and Secondary NCI Code Combinations (Continued)

NC Code	Primary NCI Code	Secondary NCI Code	Physical Interface (Mbps)	Bandwidth Profile (Mbps)	User-Network Interface	User-Network Interface Location
KRA9	08LN9.1GE	08CX9.1GE	1000	900	1000Base-T	Customer Premises
KRA9	02LNF.A02	02CXF.1GE	1000	900	1000Base-LX (SMF)	Customer Premises
KRA9	02LNF.A04	02CXF.1GE	1000	900	1000Base-SX (50 um MMF)	Customer Premises
KRA9	02LNF.A07	02CXF.1GE	1000	900	1000Base-SX (62.5 um MMF)	Customer Premises
KFL-	08LN9.1GE	08CX9.1GE	1000	1000	1000Base-T	Customer Premises
KFL-	02LNF.A02	02CXF.1GE	1000	1000	1000Base-LX (SMF)	Customer Premises
KFL-	02LNF.A04	02CXF.1GE	1000	1000	1000Base-SX (50 um MMF)	Customer Premises
KFL-	02LNF.A07	02CXF.1GE	1000	1000	1000Base-SX (62.5 um MMF)	Customer Premises

Notes:

1. SMF = Single-Mode Fiber
2. MMF = Multi-Mode Fiber
3. um = micron

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Tables

4. Performance Specifications

4.1 General

This chapter describes the performance objectives for Qwest® Metro Optical Ethernet® (MOE) service. The performance specifications affect the service quality experienced by the customer and consist of the following objectives for Qwest MOE:

- Service Activation Times
- Service Availability
- Throughput
- Latency
- Packet Loss
- VLAN Leakage
- Restoration/Fail-over Times

These performance objectives apply to all Qwest MOE Network Access Link (NAL) and core switch infrastructure architectures described in Section 2.7, Architecture and are based on congestion-free network conditions. The Qwest MOE network will randomly discard packets when congestion occurs. All shaping and policing algorithms as well as counters for gathering billing and measurement statistics are built into the MOE hardware and therefore will not impact the performance of the customer's service.

Any service degradation such as decreased throughput or dropped packets resulting from a customer's oversubscription of any of their MOE access ports will be the sole responsibility of the customer.

4.2 Service Activation Times

Service activation specifies the time from when a new or modified service order is placed to the time the service is activated and usable. The following service activation times apply to Qwest Metro Optical Ethernet service.

4.2.1 Connecting, Provisioning and Turn-up

For customers located within a building to which Qwest currently has fiber distribution, equipment deployed and acceptable riser facilities, Qwest MOE connectivity, provisioning and turn-up of service will be performed within seven (7) business days. This time period will not begin until after a service order has been accepted and entered into Qwest's provisioning systems by a Service Delivery Coordinator.

4.2.2 Bandwidth Change Requests

As described in Sections 3.2, Description of Qwest MOE Network Interfaces and 3.3, Connecting to 10Base-T, 100Base-TX and 1000Base-T Network Interfaces the Qwest cabling from the customer facing switch port to a co-located User-Network Interface (UNI) will be the same for all electrical interfaces. Then only the RJ-45 pinouts at the UNI will be different depending upon which Qwest MOE electrical interface the customer orders.

Current Qwest MOE customers may initiate a bandwidth change request for the access port speed and/or bandwidth profile on any 10Base-T, 100Base-TX or 1000Base-T UNI or Network Access Link (NAL) with a phone call. Bandwidth changes for such customers will be provisioned within four (4) business days after a service order has been accepted and entered into Qwest's provisioning systems by a Service Delivery Coordinator.

This service activation time objective applies only to bandwidth upgrades or downgrades on existing MOE electrical interfaces when a customer makes the request for the service change via a phone call. In addition, the appropriate Layer 2 and Physical Layer transport (if applicable) bandwidth must be available in the Qwest MOE network infrastructure to meet the bandwidth change request without requiring the placement of any additional equipment. For a complete description of the service activation terms and conditions including customer requirements and restrictions see the Qwest Metro Optical Ethernet Tariff.

4.3 Service Availability

Service availability is defined as the ability of a customer to exchange data packets with the Qwest Metro Optical Ethernet network at the User-Network Interface via Customer Provided Equipment (CPE). Availability specifies the percentage of time the customer's MOE service meets (or exceeds) the throughput, latency and packet loss performance objectives over any calendar month and may be expressed as:

$$\% \text{ Availability} = \frac{(\text{Total Time} - \text{Outage Time}) \times 100}{\text{Total Time}}$$

The service availability objectives for Qwest MOE are listed in Table 4-1.

Table 4-1 Service Availability

All User-Network Interfaces	Availability (Monthly)
With Single Cable Entrance	99.9%
With Dual Cable Entrances[1]	99.95%

Notes:

1. Equipment located on the customer's premises will have a single cable entrance unless the building owner elects to provide two physically separated cable entrances into the building. A second entrance to the customer's premises affords further diversity protection. When desired, it is a customer's responsibility to provide a second entrance. That second entrance must meet existing Qwest entrance facility standards. For additional information see Qwest Technical Publication 77344, *Diversity and Avoidance.*

2. Service availability includes all components of the Qwest MOE network from edge site/switch to edge site/switch within a metro region for customers with two or more locations or from edge site/switch to core switch for customers with one location in a metro.

3. Service interruptions caused by Qwest planned network maintenance activities, maintenance at the customer premises or loss of customer traffic due to malfunction of Customer Provided Equipment are excluded from the availability calculation. The Qwest MOE service availability objective assumes two hours every six months for the network maintenance window.

4.4 Throughput

The Qwest MOE bandwidth profile is a limit on the rate at which Ethernet frames can traverse the User-Network Interface (UNI). Qwest MOE service offers a better than best effort bandwidth or throughput for each customer Network Access Link (NAL). Specifically, the Qwest MOE Committed Information Rate (CIR) is the minimum bandwidth or throughput that the Qwest MOE network will deliver for at least 256 byte frames in both ingress and egress directions under normal operating conditions. For smaller frame sizes customer packets may be dropped.

Through CIR, bandwidth will be available in the increments ordered by the customer per NAL as listed in Section 2.4, Access Ports and Bandwidth Profiles. CIR rates will be met by adequate rate-limiting of the Qwest MOE Layer 2 edge and core switches, and SONET transport infrastructure where applicable.

4.5 Latency

Latency or delay is defined as the time interval between the transmission of a signal at one point and the reception or detection of the same signal at another point. Unidirectional or One-Way Delay (OWD) is the elapsed time between when a node sends a packet and when the packet is received by another node. OWD is also referred to as end-to-end transit delay.

For Qwest MOE service, the one-way delay is the time measured between when the first bit of an Ethernet frame enters the ingress User-Network Interface to when the last bit of the same frame leaves the egress User-Network Interface. Specifically, from edge site/switch to edge site/switch within a metro region for customers with two or more locations or from edge site/switch to core switch for customers with one location in a metro. The latency performance objective across a single Qwest MOE network will be as indicated in Table 4-2.

Table 4-2 Qwest MOE Network Latency

Latency (One-Way)	Objective (Monthly Average)
Maximum	Less than 25 milliseconds
Typical	Less than 15 milliseconds

Thus, over any calendar month, 100% of the successfully delivered egress frames (discarded or lost frames are not counted) will have an average one-way delay of less than 25 milliseconds. This Qwest MOE performance parameter applies to all supported Ethernet line/data rates (at the UNI), i.e. access ports and bandwidth profiles, frame sizes, alternate fiber routes where applicable and represents the total delay attributable to the Qwest MOE network.

4.6 Packet Loss

The packet loss performance parameter identifies the percentage of in-profile Ethernet frames (“green” frames that are within CIR) not reliably delivered between User-Network Interfaces (UNIs) over a given measurement interval. Any frames that are out-of-profile (“yellow” or “red” frames, i.e. exceeding the CIR) are not counted towards the number of lost frames.

Customer frames that may additionally be blocked or discarded at the User-Network Interface and not counted towards the packet loss objective include the following:

- Runts or frame sizes less than 64 bytes
- Jumbo frames with a Maximum Transmission Unit (MTU) greater than 1522 bytes
- Corrupted frames with Cyclic Redundancy Check (CRC), Frame Check Sequence (FCS) or alignment errors

Packet loss is defined as the percentage of packets that are dropped within, or between switches that are a part of, the MOE network. Specifically, from edge site/switch to edge site/switch within a metro region for customers with two or more locations or from edge site/switch to core switch for customers with one location in a metro. Qwest will engineer the Metro Optical Ethernet network to minimize packet loss such that the performance objective will not exceed that listed in Table 4-3.

Table 4-3 Packet Loss

Performance Parameter	Dropped Packets (Monthly Average)
Packet Loss Ratio	No more than 0.1%

Thus, over any calendar month the Qwest MOE network will successfully deliver at least 99.9% of a customer's packets from UNI to UNI.

4.7 VLAN Leakage

There will be zero (0) VLAN or MAC address leakage across the Qwest MOE network. Qwest Metro Optical Ethernet service does not currently support the routing or communication of traffic between VLANs.

4.8 Restoration/Fail-over Times

Where applicable, the following protocols will provide Qwest MOE Layer 1 and Layer 2 protection with the restoration/fail-over time objectives indicated. See Sections 2.7, Architecture and 2.8, Resiliency for further information on the Qwest MOE service restoration capabilities.

4.8.1 SONET

Automatic protection switching improves the availability and reliability performance of Qwest MOE service by substituting standby equipment or alternate channels when failure occurs.

The protection switch will operate and switch the failing channel to the protection system when the Bit Error Ratio (BER) on the SONET transport system exceeds 1 X 10-6 and operates at that BER for 10 consecutive seconds or longer. Once a decision is made to switch to a protection system, the additional time required to complete the switch will not exceed 50 milliseconds.

4.8.2 Spanning Tree Protocol

In case of a failure between Qwest MOE Layer 2 core switches or any core and edge switches interconnected using standard Institute of Electrical and Electronics Engineers (IEEE®) 802®.1d Spanning Tree Protocol or Per-VLAN Spanning Tree (PVST), the following will apply. Automatic reconfiguration of the spanning tree and rerouting of customer traffic by activation of a redundant path will occur in less than 50 seconds. With the implementation of PVST, a failure within a single customer VLAN will be confined to that VLAN only.

4.8.3 Link Aggregation

If a Qwest MOE link within a (Cisco) EtherChannel or IEEE 802.3-2002 (802.3ad) Link Aggregation Group fails, the traffic from the failed link will be redistributed across the remaining link(s) in less than 50 milliseconds.

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5. Maintenance

5.1 Qwest Responsibilities

Qwest is responsible for maintaining all equipment and cable on the Qwest® Metro Optical Ethernet® (MOE) network side of the User-Network Interface (UNI) at customer locations, and the transmission facility between UNIs.

Qwest will furnish the customer with a trouble reporting telephone number.

Upon receipt of a trouble alarm or report, Qwest will initiate action within twenty (20) minutes to clear the trouble and will commit to the following service restoral times for Qwest MOE:

- Four (4) hours maximum in the event of a service interruption due to an electronic component failure
- Eight (8) hours maximum if the trouble is caused by a cable failure

5.2 Customer Responsibilities

The customer is responsible for maintaining all equipment and cable on the customer side of the User-Network Interface at their locations.

In the case of service trouble, the customer or their responsible agent must sectionalize the fault or trouble and verify that the trouble is not in the customer-owned equipment or cable before calling the Qwest Customer Service Center. If the fault or trouble is isolated to the customer-owned equipment or cable, the customer is responsible for clearing the trouble and restoring the service to normal operation.

Joint testing between the customer or their agent and Qwest personnel may sometimes be necessary to isolate the trouble.

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6. Definitions

6.1 Acronyms

ADM Add-Drop Multiplexer

ANSI America National Standards Institute

AQCB® Auto Quote Contract Billing

BER Bit Error Ratio

BPDU Bridge Protocol Data Unit

Cat-5 Category 5 balanced cable

CIR Committed Information Rate

CO Central Office

CoS Class of Service

CPE Customer Provided Equipment

CSMA/CD Carrier Sense Multiple Access with Collision Detection

dBm Decibel reference to one milliwatt

DIA Dedicated Internet Access

DTE Data Terminal Equipment

DWDM Dense Wavelength Division Multiplexing

EoS Ethernet®-over-SONET

FDP Fiber Distribution Panel

GBIC Gigabit Interface Converter

Gbps Gigabit per Second

IC Interexchange Carrier

ICB Individual Case Basis

ID Identifier

IEEE® Institute for Electrical and Electronics Engineers

IOF Interoffice Facilities

IP Internet Protocol

IPX Internetwork Packet Exchange

ISO/IEC International Organization for Standardization/International Electrotechnical Commission

ISP Internet Service Provider

ITU-T International Telecommunications Union - Telecommunications Standardization Sector

L2 Layer 2

LACP Link Aggregation Control Protocol

LAN Local Area Network

LATA Local Access and Transport Area

MAC Media Access Control

MAN Metropolitan Area Network

Mbps Megabit per Second

MMF Multi-Mode Fiber

MOE Metro Optical Ethernet

MTU Maximum Transmission Unit

NAL Network Access Link

NC Network Channel

NCI Network Channel Interface

NI Network Interface

nm Nanometer

OADM Optical Add-Drop Multiplexer

OWD One-Way Delay

POP Point of Presence

PVST Per-VLAN Spanning Tree

SDC System Design Center

SMF Single-Mode Fiber

SONET Synchronous Optical Network

SPE Synchronous Payload Envelope

STP Shielded Twisted-Pair

STS Synchronous Transport Signal

STS-24c Synchronous Transport Signal level 24, concatenated

SWC Serving Wire Center

TCP Transmission Control Protocol

TIA/EIA Telecommunications Industry Association/Electronic Industries Association

UNI User-Network Interface

UPS Uninterruptable Power Supply

UTP Unshielded Twisted-Pair

VLAN Virtual Local Area Network

VPN Virtual Private Network

WAN Wide Area Network

WDM Wavelength Division Multiplexing

6.2 Glossary

Access Customers

Any of the companies that provide telecommunications service between LATAs and/or order from the Access Tariffs. Includes Interexchange Carriers.

Alternate Route

Places part of a customer's services over one route and the remainder of the services over a second route.

American National Standards Institute (ANSI)

An organization supported by the telecommunications industry to establish performance and interface standards.

Auto-Negotiation

The algorithm that allows two devices at either end of a link segment to negotiate common data service functions.

Automatic Protection Switch

A device which monitors a channel and automatically switches the channel to another facility whenever the channel fails or when specified parameters go beyond a specified threshold.

Availability

The relative amount of time that a service is "usable" by a customer, represented as a percentage over any calendar month.

Balanced Cable

A cable consisting of one or more metallic symmetrical cable elements (twisted pairs or quads).

Bandwidth

The range of frequencies that contain most of the energy or power of a signal; also, the range of frequencies over which a circuit of a system is designed to operate.

Bit (Binary Digit)

A binary unit of information. It is represented by one of two possible conditions, such as the value 0 or 1, on or off, high potential or low potential, conducting or not conducting, magnetized or demagnetized. A bit is the smallest unit of information, by definition.

Bit Error Ratio (BER)

The ratio of the number of bit errors to the total number of bits transmitted in a given time interval.

Bit Rate

The total number of bits per second transferred to or from the Media Access Control (MAC).

Bridged Local Area Network

A concatenation of individual IEEE 802® LANs interconnected by MAC Bridges.

Bridging (Multipoint Service)

Denotes the process of connecting three or more customer locations.

Byte

A consecutive number of bits usually constituting a complete character or symbol. If the length of the byte is not specified, it is conventionally assumed to have a length of 8-bits. In the Digital Data System, a byte refers to an arbitrary group of 8 consecutive bits; it does not correspond to a byte of customer data.

Carrier

An organization whose function is to provide telecommunications services. Examples are: Local Exchange Carriers, Interexchange Carriers, Cellular Carriers, etc.

Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

Carrier Sense Multiple Access with Collision Detection is a method of controlling access to a shared transmission path, particularly in Local Area Networks.

Category 5 Balanced Cabling

Balanced 100 (and 120) ohm cables and associated connecting hardware whose transmission characteristics are specified up to 100 MHz.

Central Office (CO)

A local switching system (or a portion thereof) and its associated equipment located at a Wire Center.

Central Wavelength

The average of two optical wavelengths at which the spectral radiant intensity is 50% of the maximum value.

Channel

An electrical or photonic, in the case of fiber optic based transmission systems, communications path between two or more points of termination.

Committed Information Rate (CIR)

The rate at which the network agrees to transfer information, under normal conditions, during a time interval Tc.

Customer Premises

Denotes a building or portion(s) of a building occupied by a single customer or End-User either as a place of business or residence. Adjacent buildings and the buildings on the same continuous property occupied by the customer and not separated by a public thoroughfare, are also considered the customer's premises.

Customer Provided Equipment (CPE)

Equipment owned and maintained by the customer and located on their side of the End-User Point of Termination (EU-POT) Network Interface.

Customers

Denotes any individual, partnership or corporation who subscribes to the services provided by Qwest® customers are divided into two distinct and separate categories: (1) Carriers, who provide interexchange services for hire for others, and (2) End-Users, who request services only for their own use.

Data Terminal Equipment (DTE)

A generic term for customer terminal equipment that connects to the network through a modem or through digital Network Channel Terminating Equipment (NCTE), e.g., a computer or a Private Branch Exchange (PBX).

dBm

A decibel in which the reference power is one milliwatt. Decibel reference to one milliwatt.

Diversity

Routing of customer circuits or access lines over physically separated facilities.

End Station

A system attached to a LAN that is an initial source or a final destination of MAC frames transmitted across that LAN. A Network Layer router is, from the perspective of the LAN, an end station; a MAC Bridge, in its role of forwarding MAC frames from one LAN to another, is not an end station.

End-User

The term "End-User" denotes any customer of telecommunications service that is not a Carrier, except that a Carrier shall be deemed to be an "End-User" to the extent that such Carrier uses a telecommunications service for administrative purposes without making such service available to others, directly or indirectly. The term is frequently used to denote the difference between a Carrier interface and an interface subject to unique regulatory requirements at non-Carrier customer premises (FCC Part 68, etc.).

Ethernet

A packet-switched local network design (by Xerox Corp.) employing Carrier Sense Multiple Access with Collision Detection (CSMA/CD) as access control mechanism. Throughout this document, the term "Ethernet" is used interchangeably with the IEEE Std. 802.3-2002 Edition.

Facilities

Facilities are the transmission paths between the demarcation points serving customer locations, a demarcation point serving a customer location and a Qwest Central Office, or two Qwest offices.

Frame

A unit of data transmission on an IEEE 802 LAN MAC that conveys a Protocol Data Unit (PDU) between MAC Service users.

Full Duplex

Simultaneous transmission in both directions between two points.

Gigabit Interface Converter (GBIC)

Hot-swappable input/output devices that plug into a Gigabit Ethernet port to link the port to the fiber-optic network.

Gigabits per Second (Gbps)

One billion (1,000,000,000) bits per second

Half Duplex

Transmission in either direction between two points, but not simultaneously.

Impedance

The total opposition offered by an electric circuit to the flow of an alternating current of a single frequency. It is a combination of resistance and reactance and is measured in ohms.

Individual Case Basis (ICB)

Denotes a condition in which rates and charges for an offering are developed based on the circumstances in each case.

Interexchange Carrier (IC)

Any individual, partnership, association, joint-stock company, trust, governmental entity or corporation engaged for hire in interstate or foreign communication by wire or radio, between two LATAs.

International Telecommunications Union (ITU)

An international standards group formerly know as the Consultative Committee on International Telephone and Telegraph (CCITT).

Internetwork Packet Exchange (IPX)

Novell's Layer 3 protocol that is similar to IP, and is used in NetWare networks.

Layer 1

Physical Layer of the OSI model which allows the protocol to provide the transmission of information on the transmission facility. It is concerned with the physical and electrical characteristics of the interface.

Layer 2

Data Link Layer. Provides the transfer of software between directly connected systems and detects any errors in the transfer. Establishes, maintains and releases software data links; handles error and flow control.

Layer 3

Network Layer. Provides routing and relaying through intermediate systems. Also handles segmenting, blocking, error recovery, and flow control.

Layer 4

Transport Layer. Provides the transparent transfer of software between end systems. Handles end-to-end control, multiplexing, and mapping.

Link

The transmission path between any two interfaces of generic cabling

Link Aggregation Group

A group of links that appear to a MAC Client as if they were a single link. All links in a Link Aggregation Group connect between the same pair of Aggregation Systems. One or more conversations may be associated with each link that is part of a Link Aggregation Group

Local Access and Transport Area (LATA)

A geographic area for the provision and administration of communications service. It encompasses designated exchanges that are grouped to serve common social, economic and other purposes.

Local Area Network (LAN)

A network permitting the interconnection and intercommunication of a group of computers, primarily for the sharing of resources such as data storage devices and printers.

Local Loop

The physical, cable (copper or fiber) facilities that connect the Serving Wire Center to the customer's location.

Media Access Control (MAC)

The data link sublayer that is responsible for transferring data to and from the Physical Layer.

Megabits per Second (Mbps)

One million (1,000,000) bits per second

Metropolitan Area Network (MAN)

A Metropolitan Area Network (MAN) is a data communications system which allows a number of independent data devices to communicate with each other.

Multicast

When applied to the Qwest Metro Optical Ethernet service, the functionality which supports the transport of multiple duplicate frames from a single location to multiple End-User locations within the Qwest Metro Optical Ethernet Serving Area.

Multiplexer

An equipment unit to multiplex, or do multiplexing: Multiplexing is a technique of modulating (analog) or interleaving (digital) multiple, relatively narrow bandwidth channels into a single channel having a wider bandwidth (analog) or higher bit-rate (digital). The term Multiplexer implies the demultiplexing function is present to reverse the process so it is not usually stated.

Nanometer (nm)

One billionth of one meter.

Network

The interconnected telecommunications equipment and facilities.

Network Access Link (NAL)

A MOE access channel used to connect customer facilities at the Network Interface with a corresponding Metro Optical Ethernet switch.

Network Channel (NC) Code

The Network Channel (NC) code is an encoded representation used to identify both switched and non-switched channel services. Included in this code set are customer options associated with individual channel services, or feature groups and other switched services.

Network Channel Interface (NCI) Code

The Network Channel Interface (NCI) code is an encoded representation used to identify five interface elements located at a Point of Termination (POT) at a Central Office or at the Network Interface at a customer location. The NCI code elements are: Total Conductors, Protocol, Impedances, Protocol Options, and Transmission Level Points (TLP). (At a digital interface, the TLP element of the NCI code is not used.)

Network Interface (NI)

The demarcation point at the customer's premise where Qwest's responsibility for the provisioning of service ends.

Packet

A unit of data, consisting of binary digits including data and call-control signals, that is switched and transmitted as a composite whole.

Path

The sequence of segments and repeaters providing the connectivity between two DTEs in a single collision domain. In CSMA/CD networks there is one and only one path between any two DTEs.

Point of Presence (POP)

A physical location within a LATA at which an Interexchange Carrier (IC) establishes itself for the purpose of obtaining LATA access and to which Qwest provides access service.

Point-to-Point

A circuit connecting two (and only two) points.

Port

The physical point at which energy or signals enter or leave a device, circuit, etc.

Power Budget

The minimum optical power a available to overcome the sum of attenuation plus power penalties of the optical path between the transmitter and receiver calculated as the difference between the transmitter launch power (min) and the receive power (min).

Premises

Denotes a building or portion(s) of a building occupied by a single customer or End-User either as a place of business or residence.

Protocol

The rules for communication system operation which must be followed if communication is to be effected; the complete interaction of all possible series of messages across an interface. Protocols may govern portions of a network, types of service, or administrative procedures.

Protocol Code

The Protocol (character positions 3 and 4 or the Network Channel Interface [NCI] Code) is a two-character alpha code that defines requirements for the interface regarding signaling and transmission.

Redundant Route

Places the same customer services over two separate routes.

Repeater

Within IEEE 802.3, a device that is used to extend the length, topology, or interconnectivity of the physical medium beyond that imposed by a single segment, up to the maximum allowable end-to-end transmission line length. Repeaters perform the basic actions of restoring signal amplitude, waveform, and timing applied to the normal data and collision signals. Repeaters are only for use in half duplex mode networks.

Route

The physical path established through a network for a particular circuit.

Router

A Layer 3 interconnection device that appears as a Media Access Control (MAC) to a CSMA/CD collision domain.

Service Point

Qwest MOE Service Points are geographic locations designated by the company where the MOE network can be accessed.

Serving Wire Center (SWC)

The term "Serving Wire Center" denotes a Qwest Central Office (CO) from which dial tone for the Local Exchange Service would normally be provided to the demarcation point on the property at which the customer is served.

Shielded Twisted-Pair (STP) Cable

An electrically conducting cable, comprising one or more elements, each of which is individually shielded.

Signaling

The transmission of information to establish, monitor, or release connections and/or provide network control.

Switch

A Layer 2 interconnection device that conforms to the ISO/IEC 15802-3: 1998 [ANSI/IEEE Std 802.1D, 1998 Edition] international standard.

Switch Port

A termination point on the Ethernet switch for the MOE Network Access Link. MOE ports are the physical entry points in the MOE network for Network Access Links and are the originating and terminating points for Virtual Local Area Network connections.

Synchronous Optical Network (SONET)

A standard providing electrical and optical specifications for the physical and higher layers, the first stage of which is at 51.84 Mbit/s, the Optical Channel - level 1 (OC-1). Other rates defined as OC-N where N=3 through a number not yet firm are possible.

Tag Header

A tag header allows user priority information, and optionally, VLAN identification information, to be associated with a frame.

Tagged Frame

A tagged frame is a frame that contains a tag header immediately following the Source MAC Address field of the frame or, if the frame contained a Routing Information field, immediately following the Routing Information field.

Throughput

The total capability of equipment to process or transmit data during a specified time period.

Transmission Control Protocol/Internet Protocol (TCP/IP)

Internetworking software suite originated on the Department of Defense's Arpanet network. IP corresponds to Open Systems Interconnection (OSI) Network Layer 3, TCP to OSI Layers 4 and 5.

Transparent

In communication systems, that property which allows transmission of signals without changing the electrical characteristics or coding beyond the specified limits of the system design.

Trunk

A communications path connecting two switching systems in a network, used in the establishment of an end-to-end connection.

Twisted-Pair

A cable element that consists of two insulated conductors twisted together in a regular fashion to form a balanced transmission line.

Twisted-Pair Cable

A bundle of multiple twisted pairs within a single protective sheath.

Unshielded Twisted-Pair Cable (UTP)

An electrically conducting cable, comprising one or more pairs, none of which is shielded.

Untagged Frame

An untagged frame is a frame that does not contain a tag header immediately following the Source MAC Address field of the frame or, if the frame contained a Routing Information field, immediately following the Routing Information field.

Virtual Local Area Network (VLAN)

A group of devices on one or more LANs that are configured (using management software) so that they can communicate as if they were attached to the same wire, when in fact they are located on a number of different LAN segments.

Virtual Private Network (VPN)

A private data network that makes use of the public telecommunication infrastructure, maintaining privacy through the use of a tunneling protocol and security procedures.

VLAN Stacking

A technique that lets Carriers offer multiple Virtual LANs over a single circuit.

VLAN-Tagged Frame

A tagged frame whose tag header carries both VLAN identification and priority information.

VLAN Trunking Protocol (VTP)

A Layer 2 messaging protocol that manages the addition, deletion, and renaming of VLANs on a network-wide basis.

CONTENTS

7. References

7.1 American National Standards Institute (ANSI) Documents

ANSI/TIA/EIA-568-B	*Commercial Building Telecommunications Cabling Standard*
ANSI/TIA/EIA TSB95	*Additional Transmission Performance Guidelines for 100 Ohm 4-Pair Category 5*
ANSI/TIA/EIA 526-7-1998	*Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant*
ANSI X3.230-1994 (FC-PH)	*Information Technology - Fibre Channel - Physical and Signaling Interface*
ANSI T1.223-1997	*Information Interchange - Structure and Representation of Network Channel (NC) and Network Channel Interface (NCI) Codes for the North American Telecommunications System*

7.2 International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) Publications

ISO/IEC 15802-3: 1998 [ANSI/IEEE Std 802.1D, 1998 Edition]	*Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Common specifications – Part 3: Media Access Control (MAC) Bridges*
ISO/IEC 8802-2: 1998	*Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 2: Logical Link Control*
ISO/IEC 15802-1: 1995	*Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Common specifications – Part 1: Medium Access Control (MAC) service definition*
ISO/IEC 10742: 1994	*Information technology – Telecommunications and information exchange between systems – Elements of management information related to OSI Data Link Layer standards*

ISO/IEC 11801: 2002 — *Information technology – Generic cabling for customer premises*

7.3 Institute of Electrical and Electronics Engineers (IEEE) Documents

IEEE Std 802.3-2002 — *IEEE Standard for Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

IEEE Std 802.1Q-1998 — *IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks*

IEEE Std 802.3ac-1998 — *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Supplement to Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications: Frame Extensions for Virtual Bridged Local Area Network (VLAN) tagging on 802.3 Networks*

7.4 International Telecommunications Union - Telecommunications Sector (ITU-T) Publications

ITU-T Recommendation I.430 (1995) — *Basic user-network interface – Layer 1 specification*

7.5 Telcordia Documents

ISI-SR-STS 000307 — *NC/NCI Code Dictionary*

7.6 Qwest Technical Publications

PUB 77344 — *DIVERSITY AND AVOIDANCE*, Issue B, September 2001

PUB 77368 — *CUSTOMER PREMISES ENVIRONMENTAL SPECIFICATIONS AND INSTALLATION GUIDE*, Issue E, March 2006

7.7 Ordering Information

All documents are subject to change and their citation in this document reflects the most current information available at the time of printing. Readers are advised to check status and availability of all documents.

Those who are not Qwest employees may obtain;

- ANSI documents and ISO/IEC publications from:

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  ANSI has a catalog available which describes their publications.

- IEEE documents from:

  Institute of Electrical and Electronics Engineers
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  Web: http://www.ieee.org/portal/site

- ITU-T publications from:

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  Web: http://www.itu.int/home/

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- Qwest Technical Publications from:

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